APPLIED MECHANICS Reviews

A CRITICAL REVIEW OF THE WORLD LITERATURE IN APPLIED MECHANICS AND RELATED ENGINEERING SCIENCE

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APPLIED MECHANICS REVIEWS

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SIMULATION IN SCIENCE AND TECHNOLOGY

WALTER W. SOROKA

PROFESSOR OF MECHANICAL ENGINEERING,
UNIVERSITY OF CALIFORNIA, BERKELEY, CALIFORNIA

Simulation means similarity. It emphasizes particularly the imitation of the form or behavior of something. It is widely practiced in science and technology, and simulators have become essential tools in research, industry, and education.

In the sense of this paper a simulator is any physical system deliberately assembled and operated so as to provide useful information about some other system which is of interest. The simulator need not, and usually does not, physically resemble the system of interest, although it might in suitable cases incorporate within itself such actual components of the latter as are desired and available, even to the extent of those human operators who are essential links in the prototype system (1). The term "simulator" is sometimes used in a much more restricted sense, being applied only to electronic differential analyzers, or, even more restrictively, to electronic differential analyzers operating in real (or "true") time. The current trend, however, is to use the term for such a variety of computing devices as solid and liquid electrically-conducting sheets, hydrodynamic fields, membranes, passive electrical circuits (2, 3), and for real-time and non-real-time digital computers (4, 5), and combinations of analog and digital computers operating in either real time or non-real time (6, 7).

Simulation serves three major purposes: problem solving, system design, and operational training. These are considered in order.

PROBLEM SOLVING

Two general classes of problems are involved. On the one hand, given the characteristic coefficients (which may be nonlinear or variable parameter functions) and the equations of operation of a particular system, one simulates the system and operates the simulator to obtain the relationships between certain input and output variables. On the other hand, given the relationships between input and output variables and the equations of operation of the system, one simulates these relations and operates the simulator to determine the unknown characteristic coefficients of the system (8). The first class of problems is the one most extensively treated by simulation. In fact, even the second class develops into a series of problems of the first class when trial-and-error methods are used to obtain the unknown characteristics of the system.

In problems of the first class, system characteristics are determined theoretically or experimentally, the equations of operation of the system are developed, and one of several possible simulation systems, whose characteristics and equations of operation are of the same form, or could be put into the same form, as those of the prototype system, is selected, set up, and operated. The applied inputs and measured outputs of the simulator are directly proportional to the inputs and outputs to be expected in the prototype system, the constants of proportionality (scale factors) being determined by the relative magnitudes of the units used for the known quantities in the two systems. When problems of the second class are treated in this manner, system characteristics are initially assumed and then readjusted in successive trials on the simulator until the simulator outputs match the prescribed outputs to the required accuracy.

Hydraulic Simulators. The identity of the mathematical relations between Stokes's hydrodynamic problem (*ca.* 1843) for an ideal liquid occupying a rotationally-accelerating prismatic box and Saint-Venant's torsion problem (*ca.* 1855) for a prismatic bar with the same cross section lead Thomson and Tait (*ca.* 1867) to suggest that the torsional problem could be solved by simulating it hydrodynamically. It appears that some 68 years transpired before the results of an actual experiment were disclosed (9). However, this analogy served as the forerunner of a long series of hydraulic simulators of various kinds for systems obeying the Laplace, Poisson, biharmonic, diffusion and compressible flow equations. Most of these simulators, in common with the Thomson-Tait device, are more useful in a qualitative or intuitive study of a problem than in a quantitative study.

Rayleigh (*ca.* 1893) pointed out that the stream function for viscous flow in a thin sheet and the transverse deflection of a plate clamped along the same boundaries were solutions of the same biharmonic equation. Goodier (10) showed that all such fluid motions within rigid boundaries at rest or in uniform motion simulate distributions of plane stress in a plate with the same boundaries either free from stress or subjected only to uniform normal stress. No record appears of such a simulation being actually carried out.

The experimental phases of hydraulic simulation appear to have first received prominence around 1900. Two-dimensional Laplacian fields in thin-sheet viscous flow between glass plates were made visible by means of dye streaks. The experiments were for the purpose of studying lines of force in electrostatic and in magnetic fields, any variations in dielectric constant or permeability over the field being simulated by variations in the thickness of the flow space (obtained by cutting

into a wax coating on one of the glass plates). This form of simulation has been developed recently to a high degree of efficiency by Moore in the form of "fluid mappers" (11, 12). There appears to be no limitation on the Laplacian, the Poissonian, or combinations of Laplacian and Poissonian fields that can be simulated in two dimensions by fluid mappers, including variations in field properties. Simple wells may be provided as point sources or sinks of different strengths. Distributed sources or sinks (preferably the latter) are provided by "sand-beds" consisting of high-flow-resistance beds of fine nickel or copper shot through which viscous fluid (usually water to which a small amount of Methocel had been added to increase viscosity) percolates vertically downward from a horizontal sheet-flow over the bed (distributed sink). Not only may the thickness of the flow field be varied from point to point, but also impervious obstacles of various shapes and sizes may be inserted in it.

Instead of using sandbeds, a new method to produce uniformly distributed sources (or sinks) over an area is to use a solid plate which is moved slowly to either increase or decrease the separation between it and the glass plate above it (13).

The laminar flow of viscous fluid in the annular space between two cylindrical tubes eccentrically positioned simulates the torsion problem of a hollow cylindrical bar of the same cross section (14).

The relative ease with which one-dimensional steady-state and transient diffusion problems can be simulated by water flow has led to numerous applications of this analogy, one of the most common being heat transfer. In the "Hydrocal" (15), thermal resistance, thermal storage, and temperature, are simulated, respectively, by fluid friction in capillary tubes, fluid storage in vertical standpipes, and fluid levels in the standpipes, The simulation is approximate in that it represents a limited number of perfectly-conducting lumps of finite size, each at a uniform temperature, connected in series by thermal resistances of negligible thermal capacity, through which the entire temperature drop occurs. The more standpipes are provided the more closely is the actual continuous distribution of the thermal field simulated. This was the method selected for simulation of transient thermal effects in the nose-cone re-entry problem (16), of thermal diffusion in moist soils accompanied by alternate freezing and thawing (17), and of transient heat transfer in a cross-flow heat exchanger (18). Nonlinear time-varying boundary conditions, variable physical properties of the system, thermal radiation, latent heat effects, and other variable or nonlinear effects may by simulated by varying standpipe area with height and with time, varying reservoir heights, providing variable leakage paths at various heights in the standpipes, varying the lengths of the capillary tubes with position and time, and providing switching valves between various standpipes.

The time-dependent forced motion of a piston forcing liquid into a standpipe of variable cross sectional area may be used to simulate creep and relaxation in real materials, such as prestressed concrete. Results from such hydraulic simulators have been found to agree with actual creep and relaxation tests on high tensile steel wires (19).

Of recent interest has been a series of disclosures on the simulation of shock waves in transonic compressible flow by surface waves produced in towing a large model through water of 1/4 inch depth (20, 21). The analogy applies to a hypothetical gas for which the specific heat ratio is 2. The squares of the relative depths of the thin water layer disturbed by the passing of the towed model represent relative pressures in the two-dimensional "hydraulic gas" flow about a similar obstacle. The analogy was also applied to the study of pressures and Mach number in an ejector (22) and to high-velocity combustion (23).

Membrane Simulators. The thin stretched membrane with small transverse deflections also simulates two-dimensional Laplacian and Poissonian fields. Beginning with Prandtl's disclosure (24) that the shear stress function for a prismatic bar in torsion may be simulated by this means, soap films, rubber membranes, and surfaces of separation between immiscible fluids have been widely used for this purpose. A comprehensive account of such methods is given in Ref. 25, and a discussion of accuracy (2-3%) in Ref. 26. The rubber membrane was found to hold for quite large slopes (27), contrary to previous concepts. In the case of anisotropic media, it is possible in certain cases to reduce the problem to an isotropic one by a suitable transformation of coordinates, and the membrane analogy can be used (28). Intuitively, it has been found advantageous to replace the fourth-order Lagrange equation for the deflection of thin plates by two second-order equations which represent membrane deflections (29).

An important use of the rubber membrane has been electron path determination in the dynamics of charged particles in electric fields, making use of rolling steel balls on the distended membrane. The rolling of steel balls in this instance is found inaccurate (30) and methods of simulating electric fields and space charges by rubber sheets have been developed so that electron trajectories may be found without actually using rolling balls (31).

The membrane could be combined with an electrical analogy. This was done in simulating the field of water about a drainage well in a porous soil (32), where the variable ground-water surface was represented by an adjustable rubber membrane while the water field beneath was represented by an electrolytic sheet.

Despite its inherently two-dimensional character, the membrane can simulate Laplace's equation in axially-symmetrical three-dimensional fields by subjecting it to a distributed force proportional to $1/r\ (\partial b/\partial r)$, where b = membrane height (23).

Electrolytic Tank, Electrically-Conducting Solid, and Resistance Network Simulators. An extensive bibliography on these devices is given in Ref. 34 and a comprehensive treatment in Ref. 2. Because of their simplicity, convenience and capacity to provide quick answers such simulators have found much favor not only for general potential field problems, but also in numerous other applications involving various types of partial and ordinary differential equations. Considerable emphasis has been given in recent years to resistance network simulation, at times in combination with other devices. Examples include nonsteady incompressible flow about an oscillating wing with flaps (35), limit analysis of frames (36) and electron trajectory problems (37). In combination with electronic memory elements and switches, a resistance network has been used to simulate Graetz's eigenvalue problem for temperature distribution in laminar flow through a pipe (38), as well as other partial differential equations. A unifying "cell principle" in the design of resistance network simulators leads to the representation of the Dirichlet, Neumann or Fourier boundary conditions on arbitrarily curved boundaries (39). A combination of a deep electrolytic tank and a network of capacitors was developed for three-dimensional transient heat flow studies (49).

Dynamical Analogies. Since Nickle's paper in 1925 on the force-voltage analogy and Firestone's paper in 1933 on the force-current analogy, much discussion has ensued with respect to the relative merits of the two analogies. The problem has been recently re-examined (41) on the basis of reciprocity in the equivalent electrical circuits for magnetic transducers (ideal transformers) and electrostatic transducers (ideal gyrators). Presuming an equivalent circuit means element-by-element correspondence, the force-current analog only is shown to be valid. In this connection questions of duality in electrical and mechanical circuits have received attention (42, 43). For the most part recent applications of dynamical analogies have followed standard patterns. Interesting applications of the

force-current analogy are to the statics of an aerodynamically-heated wing (44) and to flexure-torsion of a celled tube (45). Also a recent development is the simulation of rotating shafts by electrical "eight-poles," including support flexibility and gyroscopic moments on disks (46).

Electronic Analog and Digital Computers. The electronic differential analyzer, now commonly termed "electronic analog computer," or "electronic simulator," came into use as a problem-solving device in the early 1940's. Since then its use has greatly expanded and computers from simple "do-it-yourself" kits to room-filling multi-million dollar installations have become available. The fundamental unit of this computer is the very high gain (preferably "infinite") d-c operational amplifier. With appropriate input, output and feedback circuits, numerous mathematical relations ("transfer functions") may be developed between the input and output voltages. Further operations on these relations may be made with multipliers and other nonlinear function generators. Aside from computer stability problems and error considerations (47, 48), problem simulation is straightforward.

Current trends are in the direction of optimum programming (49), matrix programming (50), generalized integration (51), study of random processes (52, 53), experimental determination of system transfer functions (54), combined analog-digital machines (55), etc.

Since the advent of general-purpose electronic digital computers in the middle 1940's, the initial conception of them as strictly numerical analyzers has markedly shifted toward the more fundamental conception of them as simulators (56).

SYSTEM DESIGN

Simulation techniques in system design lean very heavily on electronic analogue and digital computers. The simulation is usually carried out in several stages from the preliminary to the final design as new information becomes available from system and component tests, and as the actual "hardware" for use in the system is manufactured. Initial simulation serves to confirm or refute basic concepts. It also serves to establish optimum values of important system constants, leading finally to a large-scale simulation in which all major components affecting system performance are accurately simulated or actually included (1). Examples of simulation in design are the Nike missile systems (57), a nuclear power plant (58), a free-piston engine (59), a distributed-parameter control system (60), a flight simulator (61), etc. The techniques are, to a large degree, those used in problem solving, except for the differences in viewpoint and scale of operations. Promising approaches to optimum system design include optimization by random search on the analog computer (62) and by nonlinear programming using gradient methods on high-speed digital computers (63).

OPERATIONAL TRAINERS

Where a human operator is required to meet situations fraught with danger, where his decisions or actions might invoke such situations, or where the cost of training the operator with the actual equipment is prohibitive except for final checkout, simulators are used for operator training purposes under as realistic conditions as possible. An aircraft operational flight simulator consists of a replica of the cockpit interior, including a full complement of properly functioning instruments, an electronic analog or digital computer for real-time solution of the aircraft flight equations, hydraulic loading devices to simulate control column "feel" and to cause cockpit accelerations in roll, pitch and to some extent in vertical translation, sound systems to simulate engine, compressor, slipstream, hydraulic and other sounds, a television display of an airport runway and approach for realistic simulation of take-off and landing, etc. (64, 65). Such simulators have been constructed not only for propeller and jet aircraft, but also for helicopters (66), nuclear power plants (67), battle radar trainers (68).

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Analytical Methods in Applied Mechanics

(See also Revs. 4395, 4396, 4397, 4416, 4418, 4421, 4422, 4423, 4430, 4431, 4471, 4488, 4577, 4613, 4621, 4629, 4672, 4679, 4692, 4738, 4840, 4860, 4864, 4889, 4890, 4891, 4894, 4897, 4913, 4953)

Book—4389. Forsyth, A. R., Theory of differential equations. Vol. 1 and 2: Exact equations and Pfaff's problem. Ordinary equations, not linear; Vol. 3 and 4: Ordinary equations, not linear. Ordinary linear equations; Vol. 5 and 6: Partial differential equations, New York, Dover Publications, Inc., 1959, xiii + 344 pp.; x + 534 pp.; xx + 596 pp. (six volumes published as three) $15 the set.

This is a reprint of a now classic study of the subject. It is a historical treatment of all phases of differential equations through the beginning of the present century. The volumes contain a wealth of material and are an excellent source for both pure and applied workers.

Y. L. Luke, USA

4390. Conte, S. D., and Miles, J. W., On the numerical integration of the Orr-Sommerfeld equation, *J. Soc. Indust. Appl. Math.* **7**, 4, 361–366, Dec. 1959.

Authors outline a format for numerical solution of $u(d^2\phi/dz^2 - \phi) - (d^2w/dz^2)\phi = 0$, where $w = \log(z/z_c)$, subject to the boundary conditions $\phi_0 = w_0$ when $z = z_0$, $d\phi/dz + \phi \to 0$ as $z \to \infty$. A table gives three sample calculations. The above differential equation is the inviscid form of the Orr-Sommerfeld equation and arises in the stability problem of parallel shear flows, while the above specific boundary-value problem has been used to study the generation of surface waves [see AMR **12**(1959), Rev. 1977].

Y. L. Luke, USA

4391. Ablow, C. M., and Perry, C. L., Iterative solutions of the Dirichlet problem for $\Delta u = u^2$, *J. Soc. Indust. Appl. Math.* **7,** 4, 459–467, Dec. 1959.

Three iterative methods of the form $\Delta u_{i+1} = bu_i[cu_i + (1 - c)u_{i+1}]$ for the Dirichlet problem $\Delta u = bu^2$ are studied. If $c = 0$, procedure converges for all $b > 0$. If $c = 1$ and b is sufficiently small, the algorithm converges and the iterates produce approximations alternately greater and less than the true solution. If $c = 2$, the procedure converges if b is sufficiently small, and the iterates are those of Newton's method for functional equations. Here the convergence is essentially quadratic.

Y. L. Luke, USA

4392. Porter, S. V., On "two-line" iterative methods for the Laplace and biharmonic difference equations (in English), *Numerische Mathematik* **1,** 4, 240–252, Sept. 1959.

Consider title equations for the rectangle. If the finite difference equivalents are such that data is on n lines, then we have an "n-line" method. Author shows that "two-line" iterative methods can be reduced to two "single-line" equations which are easily solved. Estimates on rate of convergence are developed.

Y. L. Luke, USA

Computing Methods and Computers

(See also Revs. 4391, 4426, 4428, 4456, 4518, 4678, 4682, 4935)

4393. Herfurth, G., The maximum propagated error (in German), *Technik* **14,** 8, 536–537, Aug. 1959.

A rule of thumb determines the propagated error in an addition (subtraction) of x and y as the sum of their absolute errors and in a multiplication (division) of x and y as the sum of their relative errors.

Author shows that this rule might overestimate the propagated error considerably if applied to additions or multiplications of functions in x and y. In that case it is preferable to use $\Delta f = f_x \Delta x + \cdots + f_y \Delta y$.

P. F. De Neeve, Canada

4394. Lauchli, P., Iterative solution and error estimate in approximation methods (in German), *ZAMP* **10,** 3, 245–280, May 1959.

Part 1. Succinct informative review of linear least-squares approximation theory. Part 2. Discussion of numerical techniques for solving the equations of approximation theory: Basically $k_i = \sum_{j=1}^{n} a_{ij}z_j$, $i = 1,2,\ldots,n$, k_i given, z_j to be found, a_{ij} known and fixed. Included are conjugate gradients, treated in detail. Part 3. Methods of estimating error as iterative procedure completes each step. Part 4. Examples. (Most of the material seems to be known although the exposition is new and effective.)

B. R. Gelbaum, USA

4395. Rutishauser, H., On the Gauss-Jordan method of matrix inversion (in German), *ZAMP* **10,** 3, 281–291, May 1959.

Let variables y be homogeneous linear functions of variables x. Operation is introduced that moves one x to left side of equations and one y to right. This operation induces nonsimilarity transformation on matrix of equations. Iteration according to specified scheme yields x's as functions of y's, giving inverse of matrix by method suited to machine computation.

B. Hoffmann, USA

4396. Clerc, D., Study of dominant and subdominant proper values (eigenvalues) of a real or complex matrix (in French), ONERA Pub. 72, 53–58, Sept./Oct. 1959.

Paper is an extension of a method previously considered for the real case only [AMR **10**(1957), Rev. 2779]. Unfortunately the method coincides with F. L. Bauer's "stair-step" iteration [AMR **11**(1958), Rev. 7; see also *J. Assn. Comp. Macb.* **5,** 246–57, 1958], but imposes unnecessary restrictions. Thus if proper values $\lambda_1, \lambda_2, \ldots,$ λ_k are required where $|\lambda_1| \geq |\lambda_2| \geq \ldots \geq |\lambda_k| > |\lambda_{k+1}| \geq \ldots,$ author requires (unnecessarily) that $\lambda_1, \ldots, \lambda_{k-1}$ be found first.

A. S. Householder, USA

4397. Szidarovszky, J., Practical method for solving differential equations with nonconstant coefficients (in German), *Acta Techn., Acad. Sci. Hungaricae, Budapest* **24,** 1/2, 85–94, 1959.

Method describeu consists in dividing the required range of the solution into smaller sections, in which the variable coefficients of the derivatives can be considered as constants. The particular solutions of replacing equations with constant coefficients can be obtained by step-by-step operation, beginning with the first section with respect of joining conditions on the boundaries of single sections. Simple example (axially and transversely loaded beam on two supports with nonuniform cross section) showing the expedience of the method described is introduced.

V. Kopriva, Czechoslovakia

4398. Borwein, D., and Mitchell, A. R., The effect of boundary conditions and mesh size on the accuracy of finite difference solutions of two-point boundary problems (in English), *ZAMP* **10,** 3, 221–232, May 1959.

Paper examines the accuracy of boundary-value techniques based on finite difference methods as applied to the numerical solution of an ordinary differential equation on the second order with constant coefficients with two-point boundary conditions. It is shown that under certain circumstances the approximate solution of the difference equation, replacing the original differential equation, could differ considerably from the rigorous solution of the original. Conditions for this behavior of the approximate solution are introduced and errors for a particular case computed. Further, it is pointed out that the seriousness of the errors arising in numerical solutions is increased considerably with the order of the replacing difference equation.

V. Kopriva, Czechoslovakia

4399. Matiukhin, N. Ia., Linear transformations of binary codes, *Automation and Remote Control* **19,** 8, 759–770, May 1959. (Translation of *Avtomatika i Telemekhanika USSR* **19,** 8, 776–787, Aug. 1958 by Instrument Society of America, Pittsburgh, Pa.)

An algebraic theory is presented of binary codes with a fixed number of elements per code, in which coding symbols are represented as vectors. If we start from the so-called normal code expressing coded numbers in a binary system, then every other code is obtained by a certain transformation in the considered vector space. The most important of the finite group of these transformations is the subgroup of linear transformations, i.e. of transformations performed by means of regular matrices. The proposed vector interpretation thus makes possible simultaneous investigation of the properties and ways of realization of a wide class of codes, whereas in previous works some single codes have been examined separately.

Several examples show how to determine the transformation matrix from given properties of the code. Furthermore schemes are presented of relay contact networks suitable for obtaining appropriate transformation matrix. The example of Gray code (for converters of continuous quantities into discontinuous ones) shows very clearly that the proposed method, besides its own theoretical significance, can be a good tool for the physical realization of various codes.

Z. Rezny, Czechoslovakia

4400. Voronov, A. A., and Sokolov, G. N., Digital integrator device for programming second-order curves, *Automation and Remote Control* **20,** 2, 169–176, Jan. 1960. (Translation of *Avtomatika i*

Telemekanita, USSR **20,** 2, 176–183, Feb. 1959 by Instrument Society of America, Pittsburgh 22, Pa.)

The feasibility of applying digital analog computers to the programming of second-order curves is investigated. The circuit of a programming device applied to a milling machine for the working of profiles consisting of sections of straight lines and circles is presented. From authors' summary

4401. Leiner, A. L., Notz, W. A., Smith, J. L., and Weinberger, A., Pilot—a new multiple computer system, *J. Assn. Comput. Machy.* **6,** 3, 313–335, July 1959.

The PILOT data processor is a high-speed multiple computer system, more than 100 times faster than SEAC. It contains three interconnected computers for rapid processing of data, and also contains multiple input-output channels for rapid transfer of data into and out of the system. All of these units operate concurrently in a coordinated fashion. A summary description is given of the over-all logical plan of the system, including the principal characteristics of the first computer, the second computer, the third computer, the internal controls, and the external controls.

The system combines internal processing capabilities that are fast and versatile with external communication capabilities that are exceptionally flexible. This combination permits the internal power of the machine to be exploited readily by the outside world—either by other automatic devices or by human operators.

From authors' summary by R. T. Harling, USA

4402. Snyder, W. M., Hydrologic studies by electronic computers in TVA, *Proc. Amer. Soc. Civ. Engrs.* **86,** HY2 (*J. Hydr. Div.*), 1–10, Feb. 1960.

Application of electronic computers in TVA watershed studies is presented. A comprehensive multiple regression analysis program in developing and studying hydrologic prediction equations is illustrated by discussion of numeric results of fitting two equations to data. From author's summary

Analogies

(See also Revs. 4399, 4714, 4723, 4818, 4928, 4934, 4948)

4403. Edamoto, I., An electrical method for solving the torsion problem of a cylindrical body, *Technol. Rep. Tohoku Univ.* **21,** 1, 51–75, 1956.

The paper describes a new analogy for the solution of Poisson's equation. The model is a thin plate made of a dielectric material placed between a metal plate and an electrolytic tank. An alternating current is applied between the electrolytic solution and the metal plate. Electric quantities analogous to equi-potential lines, shear stress, as well as total torque can be measured. The method is equally applicable to multiply connected bodies.

M. L. Pei, USA

4404. Edamoto, I., and Kanayama, M., Experimental study of torsion problems by means of a special electrolytic tank, Parts 1, 2 and 3: Circular cylinder having a lengthwise radial cut; Twist drill; Measurement of moment, *Technol. Rep. Tohoku Univ.* **23,** 1, 1–20, 1958.

Experiments based on authors' a-c electric analogy [see preceding review] are described. Fairly elaborate electronic instrumentations were employed. Where theoretical results are known, the experimental values show very good agreement.

M. L. Pei, USA

4405. Shearer, J. L., Electric network analog study of viscous flow normal to parallel, evenly spaced cylinders, *Text. Res. J.* **29,** 6, 467–476, June 1959.

To idealize the very complicated problem of viscous flow through textile fibers, author considers the case of "creeping" flow normal to an infinite hexagonal array of parallel circular cylinders. The familiar biharmonic equation involving the stream function is solved for the prescribed boundary conditions. Such solution is necessarily handled by approximation methods. Author accomplishes this by transforming the problem to a new coordinate system, in which the boundary conditions are more simply introduced. Equations are then expressed in finite difference form and solved by an electric network analog.

Determination of the stream function allows the pressure drop to be determined. Results are then expressed in terms of the Carmen-Kozeny equation, normally identified with porous media flow. The so-called Kozeny constant is finally expressed as a function of porosity. Four ratios of diameter-to-cylinder spacing were solved on electric network analog. It was found that flow resistances were about four times as great as experimental values; author claims discrepancy was likely due to uneven spacing of fibers in the real case. However, variation in flow resistance as a function of porosity, on a relative basis, was approximately the same in idealized model and experimental results. It is concluded that Carmen-Kozeny formula is inadequate for predicting flow resistance in fiber beds. R. B. Banks, USA

Kinematics, Rigid Dynamics and Oscillations

(See also Revs. 4422, 4423, 4430, 4448, 4514, 4523, 4623, 4663, 4719, 4876, 4885, 4889, 4890, 4891, 4894, 4898)

Book—4406. Rosen, E., Three Copernican treatises, New York, Dover Publications, Inc. 1959, x + 283 pp. $1.75. (Paperbound)

This new Dover edition, first published in 1959, is an unabridged and revised republication of the first edition, to which has been added an annotated Copernicus bibliography, 1939–1958.

Ed.

4407. Spotts, M. F., Kinematic properties of the three-gear drive, *J. Franklin Inst.* **268,** 6, 464–473, Dec. 1959.

Equations for three-gear drive giving nonuniform motion are presented. With proper proportions output may reverse or reach zero periodically. Simple device for smooth speed variations.

C. R. Freberg, USA

4408. Tondl, A., On the stability of a flexible shaft with one disk, subjected to forces of internal and external friction and disk weight (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 1, 21–25, Jan. 1958.

The disk is taken in the midst of the shaft and remains perpendicular to the rotation axis; the shaft mass is neglected. Founded on some earlier work of F. M. Dimentberg [see AMR **10**(1957), Rev. 1680], author assumes for the external friction-force a viscous damping and for the internal friction-force a linear function of the relative velocity ζ^* or a nonlinear function $h\,\frac{\zeta^*}{|\zeta^*|}$. Proceeding in a straightforward manner, author gets his first-order equations by a well-known variational approach; applying to them the Routh-Hurwitz criteria for stability, he succeeds in expressing the critical value for the angular velocity ω. The whole analysis is done in a very elegant way, using the complex notation. There are some obvious misprints in formulas (20) and (22).

Finally the author gives a qualitative discussion of the influence of the rotor weight, the shaft stiffness and the characteristic values of the coefficients for the internal and external friction-forces on the region of stability. J. J. P. Geerlings, Holland

4409. Voronkov, I. M., Determination of the angle of inclination of a rectilinear brachistochrone taking friction into account (in Russian), *Nauchn. Trudî Mosk. Gorn. In-ta* no. 17, 5–10, 1956; *Ref. Zh. Mekh.* no. 2, 1959, Rev. 1128.

Making use of geometrical figures a solution is given for two problems on the angle of inclination of a rectilinear brachistochrone to a material point when friction is present. The coefficient of friction is assumed to be a constant.

G. I. Drukhsherstov

Courtesy Referativnyi Zhurnal, USSR

4410. Bogoiavlenskii, A. A., On particular cases of motion of a heavy rigid body about a fixed point, *Appl. Math. Mech.* (*Prikl. Mat. Mekh.*) **22,** 5, 873–906, 1958. (Pergamon Press, 122 E. 55th St., New York 22, Y. Y.)

The present paper shows that Kovalevskaia's method [*Acta Math.* **12,** 177–232, (1889)] can be used for finding particular cases of integrability of the equations of motion of a heavy rigid body about a fixed point. The author takes the equations of motion not in the form as given by Euler but in the form obtained by Hess [*Math. Ann.* **37,** 153–181, (1890)]. He then shows that particular cases of integrability can be derived if in the right-hand sides of the Hess differential equations radicals are absent, or the center of gravity of the body is located in the plane through the axes of equal moments of inertia

E. Leimanis, Canada

4411. Yershov, B. A., and Sobolev, Yu. I., Examples of the large-scale stability of certain dynamic systems (in Russian), *Uch. Zap. LGU* no. 217, 17–21, 1957; *Ref. Zh. Mekh.* no. 8, 1958, Rev. 8388.

Some criteria are developed for the stability of nonlinear systems in the presence of large initial perturbations. The derivation of the stability criteria is based on some considerations by S. A. Stebakov [*Dokladî Akad. Nauk SSSR* **95,** no. 3, 1954]. As an example, one of these criteria may be cited here: The necessary and sufficient conditions for the asymptotic stability of a system

$$\dot{x}_i = f_i(x_i, x_{i-1})\, A_i x_i + F_i x_{i-1} + \varphi_i(x_i, x_{i-1}) \quad (i = 1, \ldots, n)$$

wherein

$$A_i = \left(\frac{f_i}{x_i}\right)_{\substack{x_i=0 \\ x_{i-1}=0}}, \quad B_i = \left(\frac{\partial f_i}{\partial x_{i-1}}\right)_{\substack{x_i=0 \\ x_{i-1}=0}}$$

are given by the inequalities

$$\left|\frac{\partial f_i}{\partial x_i} \Big/ \frac{\partial f_i}{\partial x_{i-1}}\right| > \left|\frac{A_i}{B_i}\right|$$

$$A_i < 0, \quad \prod_{i=1}^{n} \left|\frac{A_i}{B_i}\right| > 1$$

The proofs given in the paper are incomplete; more general stability criteria are given in the literature for some of the systems investigated, e.g., Example 3. The replacement of the accepted terminology of Lyapanov's second method by terms such as "the Ω-shell," "internal conduction," is unjustifiable, since the examples adduced do not go beyond the ordinary range of problems of the Lyapunov theory.

N. N. Krasovskii

Courtesy Referativnyi Zhurnal, USSR

Book—4412. Gray, A., A treatise on gyrostatics and rotational motion, theory and applications, New York, Dover Publications, Inc. 1959, xx + 530 pp. $2.75. (Paperbound)

This new Dover edition, published in 1959, is an unabridged and unaltered publication of the work first published in 1918.

Ed.

4413. Zhak, S. V., Motion of a gyroscope with a housing filled with liquid (in Russian), *Sb. Nauchvo-tekhn. Rabot. Azovo-Chernomorsk. In-ta Mechaniz. S. Kh.* no. 10, 297–311, 1957; *Ref. Zh. Mekh.* no. 2, 1959, Rev. 1432.

Conforming with Zhukovskii's theory ["The motion of a solid body having cavities filled with a homogeneous liquid in the form of drops," Collection of papers, 1949, 2], author investigates the motion due to its own specific gravity of a dynamically symmetrical heavy solid body with a symmetrical cavity filled with an ideal incompressible liquid when the axis of symmetry of the cavity coincides with the axis of symmetry of the gyroscope and the center of gravity of the system does not coincide with an immovable point. In addition it is assumed that the vortex of velocity is the same for all the particles of the liquid in the cavity (a "quasi-solid" motion). The expression for velocity is recorded in the form of

$$v = \Lambda[\Psi(\Omega - H)] + H \times r \qquad [1]$$

where Ω is the angular velocity of the gyroscope, r the radius vector, Ψ a function for the vector introduced by Zhukovskii, $2H$ is the vortex of velocity. Additions are made to Eq. [1] of Helmholtz's equation for vortices and of an equation for the kinetic moment of the system. By comparing the expressions for the kinetic moment and the kinetic energy for the system author is able to conclude that the tensor of inertia of the system is replaceable by the tensor of inertia of the "converted" solid body and that, in addition, it is supplemented by the connected gyroscope rotating with an angular velocity of $H(t)$. The question is then taken up of whether the quasisolid motion is possible and the conclusion is reached that it is possible in two cases: (1) when the cavity assumes the form of an ellipsoid of rotation (or is open) and (2), when the gyroscope rotates round the vertical axis of symmetry (a dormant gyroscope). The first five integrals for the equation of motion are obtained. The small oscillations of the gyroscope round the vertical position of equilibrium are investigated. Author derives a characteristic equation, which proves to be an equation not of the second but of the third degree, discusses the different possible cases and points out the difference between a gyroscope with a liquid and a monolithic gyroscope. In order to substantiate the hypothesis of "quasisolid" rotation an example is investigated of the propagation of vortices in a viscid liquid inside a round infinite tube, rotating about its own axis with a constant angular velocity of ω_o. The existing solution for this problem shows that much time is required to create a state of "quasisolid" rotation. On this finding, the conclusion is arrived at that the created "quasi-solidarity" will be only slightly affected by disturbances and that consequently the hypothesis of "quasisolidarity" is fully established.

A. K. Nikitin

Courtesy Referativnyi Zhurnal, USSR

4414. Stewartson, K., On the stability of a spinning top containing liquid, *J. Fluid Mech.* **5,** 4, 577–592, May 1959.

A criterion is obtained for the instability of a heavy top with a closed cylindrical cavity partly filled with liquid and rotating rapidly.

Assumptions made in the theory include (1) axis of cylindrical cavity is parallel to axis of symmetry of top, (2) gravitational forces in liquid are negligible compared with centrifugal forces, (3) undisturbed free surface of liquid is a cylinder with axis parallel to axis of symmetry, (4) top has been rotating long enough for liquid to have taken up angular velocity of top before being disturbed, and (5) effects of viscosity are negligible in disturbed motion.

It is shown that, for a cylindrical cavity with or without air space, there is an infinity of ranges of the cavity length/diameter ratio for which the top is unstable at all rotational speeds. This

instability occurs when the period of nutation of the casing is sufficiently near to any one of an infinity of normal modes of the contained liquid.

The theoretical criterion for instability may be expressed in the form $-1 \leqslant A \leqslant 1$, where A depends on the geometry of the system and the filling-ratio of the cavity. Its assessment in particular cases is facilitated by the inclusion of an abridged version of tables prepared by D. C. Gilles.

Experiments conducted by G. N. Ward yield an experimental criterion of $-3.9 < A < 2.7$ at the principal instability.

Consideration is given to (1) the effect of gravity on the liquid, (2) displacement of the axis of rotation from the axis of the cylinder, (3) nonlinearities, and (4) friction in the gimbal bearings as possible sources of discrepancy between the theoretical and experimental criteria. S. Kirkby, England

4415. Rumyantsev, V. V., On stability of equilibria of a rigid body with liquid-filled cavities, *Soviet Phys.-Doklady* **4,** 1, 46–49, Aug. 1959. (Translation of *Doklady Akad. Nauk SSSR (N.S.)* **124,** 2, 291–294, Jan./Feb. 1959 by Amer. Inst. Phys., Inc., New York, N.Y.)

Using the concepts and definitions of Lyapunov, the stability of equilibrium of a rigid body with cavities incompletely filled with a homogeneous incompressible ideal fluid is considered theoretically. Assuming that the external forces are potential forces, and making use of the conservation of energy ($T + V = \text{const}$), it is shown that if at an equilibrium position the potential energy of the system has an isolated minimum, then this equilibrium position is stable. Author indicates that this theorem would also be valid in the case of a viscous fluid. M. Morduchow, USA

4416. Kuzmak, G. E., On the computation of asymptotic solutions corresponding to nonclosed integral curves of the "standard" equation, *Soviet Phys.-Doklady* **4,** 2, 309–312, Oct. 1959. (Translation of *Doklady Akad. Nauk SSSR (N.S.)* **125,** 5, 992–995, Mar./Apr. 1959 by Amer. Inst. Phys., Inc., New York, N. Y.)

Author considers the differential equation [1] $y'' + \varepsilon f(\tau,y)y' + F(\tau,y) = 0$ ($' = d/dt$), where ε is a small parameter, and $\tau = \varepsilon t$ is slowly varying time. He seeks an asymptotic formula $y = y_0(\tau,\omega) + \varepsilon y_1(\tau,\omega)$ which will approximate solutions of [1] to terms of order ε^2 on a preassigned interval $0 \leq t \leq \tau_0/\varepsilon$. Here ω is related to t by $d\omega/dt = \varphi(\tau)$. The function $y_0(\tau,\omega)$ is a properly chosen solution of the "standard" equation [2] $\varphi^2(\tau)\,\partial^2 y_0/\partial\omega^2 + F(\tau,y_0) = 0$. The function $y_1(\tau,\omega)$ satisfies a more complicated differential equation, also given by the author. It is also assumed that f and F are sufficiently smooth, that both are periodic in y with period T_y independent of τ, that f is an even function of y, and that F is an odd function of y. The author is particularly concerned with the case when the solutions of [2] are not necessarily periodic, so that not all phase plane loci corresponding to [2] are closed curves. As a typical example he considers a simple pendulum where f is independent of y, and $F = g(\tau)\sin y$. If $g(\tau)$ is small at first but then grows rapidly, a solution of [2] can change from aperiodicity to periodicity with a corresponding shift of qualitative behavior of solutions of [1].

The paper is completely mathematical, and the presentation is of necessity sketchy because the author is limited as to space. W. S. Loud, USA

4417. Postolnik, Yu. S., The dynamics of an elastically-mobile thread (a rope) of variable length loaded at one end in the case of high lifts (in Ukrainian), *Prikl. Mekh.* **3,** 2, 186–195, 1957; *Ref. Zh. Mekh.* no. 8, 1958, Rev. 9114.

In view of the complexity of the solution of this problem by the method of characteristics [N. P. Neronov: *Prikl. Mat. Mekh.* **1,** 1, p. 91, 1937], author has used the approximate solution of G. N. Savin [*Ukr. Mat. Zh.* **6,** 2, 126–139, 1954], considering the internal and external resistances, founded on the use of the method of moments, and statement of the required function of the absolute elongation of the rope, in the form

$$u(x,\ t) = x\varphi(t) + x^2\Psi(t).$$

The method used furnishes a system of an infinite number of ordinary differential equations of which only the first two are retained, sufficient for determining the unknown functions $\varphi(t)$ and $\Psi(t)$, with approximate initial conditions. The rope tension is given by the expression:

$$T = K\frac{\partial u}{\partial x} + \alpha\frac{\partial^2 u}{\partial x \partial t}$$

wherein K is the coefficient of rigidity of the rope, and α the coefficient of internal resistance. Since the latter is very small, it is possible to assume

$$T = K\frac{\partial u}{\partial x} = K\,[\varphi(t) + 2x\Psi(t)]$$

The value of T is calculated for the point at which the rope is wound on the drum, $x = l$. For small hoisting heights, only the function $\varphi(t)$ is retained, and one differential equation determining this function. The curve of variation of the peripheral velocity on the drum is further assumed to follow a trapezoidal law, and an asymptotic expression is found for the rope tension T for large values of the coefficient of rigidity K, for each of the three segments of the said curve. To avoid complication, the majority of the time functions appearing in these expressions are not written out. The resulting equations for T show that, generally speaking, the dynamic stresses in the rope do not fade. The presence of fading in the initial segment of the tachogram (uniform rotation of the drum) requires an inequality to be satisfied, linking the coefficient α with the peripheral velocity v_0 on the drum:

$$\alpha \geqslant \frac{v_0 Q}{2g}\left(1 + \frac{1}{3}\frac{P}{Q} + \frac{4}{45}\frac{P^2}{Q^2}\right)$$

wherein P is the weight of the vertical part of the rope, Q the weight of the end load, and $P/Q \leqslant 0.7$, i.e. the height of hoisting is not above 1200–1400 meters. Since the total tension on the rope contains both dynamic and static components, the latter of which decreases during hoisting of the load, owing to shortening of the vertical part of the rope, author comes to the conclusion that, with fulfilment of the above-mentioned inequality, the total rope tension must likewise decrease, and the strength analysis of the rope may be reduced to determination of the first peak in the value of the maximum tension. In the numerical example given, this peak occurs 0.8 sec after the beginning of motion of the load; the author determines its value by one of the suggested formulas. It must be remarked that the assumption of proportionality between the internal resistances and the rate of change of the deformations has not been proved. N. P. Neronov

Courtesy Referativnyi Zhurnal, USSR

4418. Huan, Wen-Ho, A simplified form of the method of the small parameter for solving nonlinear differential equations of oscillation (in Chinese), Khaerbin gu-ne dasyu Syehbao no. 2, 103–113, 1957; *Ref. Zh. Mekh.* no 8, 1958, Rev. 8391.

A practical method is presented for obtaining the generating solution of the differential equation of the oscillation of nonautonomous, quasilinear systems with one degree of freedom in the presence of resonance

$$\ddot{x} + k^2 x + f(t) = \mu F(t, \dot{x}, x, \mu)$$

On the basis of the results given in Chapter 1 of the book by I. G. Malkin: "Some problems of the theory of nonlinear oscillations" [Moscow, Gostekhizdat, 1956], author demonstrates that in a num-

ber of cases [when $f(t)$ is a harmonic function, and the terms of the function $F(t, x, \dot{x}, \mu)$ are evidently time-dependent and harmonic] the generating solution is advantageously sought in the form

$$x_0 = A_0 \cos(nt + \alpha)$$

with an ensuing transition of the origin

$$t' = t + \frac{\alpha}{n}$$

In this case, the parameters A_0 and α are easily found from the integrals determining the periodicity of the solution. These integrals are presented in the form

$$P_2(A_0, \alpha) = \int_0^{2\pi} F\left(\tau - \frac{\alpha}{n}, A_0 \cos n\tau + \varphi\left(\tau - \frac{\alpha}{n}\right), -\right.$$

$$\left. - nA_0 \sin n\tau + \varphi\left(\tau - \frac{\alpha}{n}\right), 0\right) \sin n\tau d\tau = 0$$

$$Q_2(A_0, \alpha) = \int_0^{2} F\left(\tau - \frac{\alpha}{n}, A_0 \cos n\tau + \varphi\left(\tau - \frac{\alpha}{n}\right), -\right.$$

$$\left. - nA_0 \sin n\tau + \dot{\varphi}\left(\tau - \frac{\alpha}{n}\right), 0\right) \cos n\tau d\tau = 0$$

This also simplifies calculation, and shows the existence of a periodic solution, with the conditions for the stability thereof.

V. I. Osorin

Courtesy Referativnyi Zhurnal, USSR

4419. Saelman, B., The motion and loading of a hinged ramp which supports a sliding mass, *ASME Trans.* **82** E (*J. Appl. Mech.*), 1, 177–181, Mar. 1960.

Equations of motion of a hinged ramp supporting a sliding mass, which moves at constant velocity, are derived; these are shown to have no closed solution when the ramp is spring supported or when the cylinder force is proportional to the square of the velocity. For small velocities of the sliding mass the Coriolis term may be neglected and a good approximation to the solution of the equations is obtained by means of the Madelung transformation. The solutions by special methods are compared to the solutions obtained by standard numerical methods.

From author's summary

4420. Snowdon, J. C., and Parfitt, G. G., Isolation from mechanical shock with one- and two-stage mounting systems, *J. Acoust. Soc. Amer.* **31,** 7, 967–976, July 1959.

Authors discuss title problem considering acceleration, relative displacement and displacement. They point out influence of each of these parameters on shock damage and introduce a new, simple and apparently realistic shock input. Abstract states that heavy damping is beneficial, but conclusions in body of paper do not confirm this. Authors also appear to conclude that two-stage mounting is not effective in most shock problems.

Reviewer believes study to be a distinct contribution to field but that results and conclusions would be substantially different if nonrigid and standing wave effects were included. There is a large amount of numerical information presented which will become more useful to designers and analysts as it is more thoroughly digested and presented in different ways.

R. Plunkett, USA

4421. Pestel, E., Dynamics of structures by transfer matrices (in English), AFOSR TR 59-95 (Lehrstuhl und Institut für Mechanik, Technische Hochschule Hannover, Germany, TR 1), 182 pp., June 1959.

Report is comprehensive account of use of transfer matrices in structural analysis. Transfer matrix relates the state variables (displacement, slope, shear, moment, etc.) at one station in a structure to those at an adjoining station. State variables at boundaries are related by continued products of transfer matrices.

New approach in this work is in derivation of transfer matrices from system of n first-order differential equations rather than one n^{th}-order differential equation. Transfer matrix is exponential matrix function which is replaced by polynomial by Cayley-Hamilton theorem.

Catalogue of transfer matrices for straight, curved and twisted beams is given: method is illustrated for calculation of rotating disks, structural analysis of aircraft components and calculation of thin plates.

Difficulties in numerical calculation are fully discussed and modifications introduced to counter these.

R. D. Milne, England

Instrumentation and Automatic Control

(See also Revs. 4399, 4401, 4412, 4540, 4629, 4726, 4863, 4897)

4422. Solodov, A. V., Conversion of output initial conditions in a linear system with variable parameters into an equivalent input signal, *Automation and Remote Control* **19,** 7, 645–651, Apr. 1959. (Translation of *Avtomatika i Telemekhanika, USSR* **19,** 7, 654–660, July 1958 by Instrument Society of America, Pittsburgh, Pa.)

The response of a linear system with time-varying parameters is required for a given set of initial conditions. The method involves the specification of an equivalent input consisting of a combination of various order delta functions such that the response of the system to the latter input is the same as that in the original situation. This problem has previously been discussed by Zadeh [*J. Appl. Phys.* **22,** 6, 782–786, June 1951; AMR **5** (1952), Rev. 26]; however Solodov states that an error exists in Zadeh's paper and shows that the equivalent input depends upon the derivatives of the parameters at the instant at which an input is applied whereas Zadeh's result did not include this factor. The result is confirmed by an example solved both by the method of the paper and by an alternative method.

R. J. Kavanagh, England

4423. Kardashov, A. A., and Karniushin, L. V., Determination of system parameters from experimental frequency characteristics, *Automation and Remote Control* **19,** 4, 327–338, Feb. 1959. (Translation of *Avtomatika i Telemekhanika, USSR* **19,** 4, 334–345, Apr. 1958 by Instrument Society of America, Pittsburgh, Pa.)

A method is given for determining the parameters of linear links and automatic control systems from their approximate experimental amplitude-phase characteristics. By interpolation, approximate values are found for the values of the coefficients in the analytic expression for the amplitude-phase characteristics, and then corrections to the coefficients thus found are computed by the method of least squares.

The method is applicable to transfer functions with arbitrary polynomials in numerator and denominator, and gives sufficiently accurate results when calculations are done by slide rule.

Examples clarify the computational steps.

From authors' summary by H. D. Block, USA

4424. Raikhel', N. L., The calculation of transient responses in coordinated automatic control systems, *Automation and Remote Control* **19,** 11, 994–1003, June 1959. (Translation of *Avtomatika i Telemekhanika, USSR* **19,** 11, 1016–1026, Nov. 1958 by Instrument Society of America, Pittsburgh, Pa.)

Author investigates the transient response of control systems when conditions of autonomy are disturbed. The latter property is defined as a possibility to control one quantity independently of

other ones. Author defines as degree of autonomy m produced by a disturbance the difference between two time constants of servomotors related to one of them. Omitting a series of intermediate transformations the following conclusions are obtained. The transient response of a nonautonomous (in the above sense) coordinated control system consists of two components, one of which represents this response for the autonomous behavior and the other relates to the departure from the "autonomy."

The second part of the problem relates to stability; the conclusion is: the nonautonomous coordinated system involving two controlled quantities will be stable if the corresponding autonomous system is stable and if the point $(-1; j0)$ in the complex plane is outside the hodograph of the function $W(z) = B_1(z)\,m/B_0(z)$ where B_1 and B_2 are certain coefficients of the characteristics equation.

Author completes his paper by extending his investigation from two to n controlled quantities. Appendix indicates the procedure for constructing hodograph curves.

N. Minorsky, France

4425. Lindgren, B. W., On Samulon's formula for frequency response from step response, *SIAM Rev.* **1**, 1, 47–49, Jan. 1959.

4426. Webster, J. L., and Schultz, D. N., Analog computer technique for plotting frequency response, *ARS J.* **30**, 3, 273–275 (Tech. Notes), Mar. 1960.

This article describes a direct method of obtaining frequency response curves during analog computer studies. The system under study is driven by a constant amplitude, varying frequency sine wave. System output is then rectified and recorded on the Y axis of a recorder whose X axis is swept at the same rate as that of the driving frequency. A suitable driving function can be generated using analog computer components.

From authors' summary

4427. Kukztenko, V. I., Choosing optimum parameters for linear dynamic systems (in Russian), *Trudi Mosk. Aviats. In-ta* no. 84, 30–32, 1957; *Ref. Zh. Mekh.* no. 2, 1959, Rev. 1172.

A linear system subjected to the simultaneous action of random and nonrandom signals is examined. Criteria are proposed for the minimum mean quadratic error for a random signal and for lack of distortion in relation to the constrained vibrations of the nonrandom signal. It is shown that the problem of selecting the optimum parameters then becomes the problem of the relative minimum.

M. A. Aizerman

Courtesy Referativnyi Zhurnal, USSR

4428. Matveev, P. S., and Plotnikov, V. N., Nomograms for the analysis and synthesis of automatic stabilization systems, *Automation and Remote Control* **20**, 7, 957–961, Mar. 1960. (Translation of *Avtomatika i Telemekhanika, USSR* **20**, 7, 983–987, July 1959 by the Instrument Society of America, Pittsburgh 22, Pa.)

Nomograms which may be used for the analysis and synthesis of automatic stabilization systems are given for the desirable logarithmic amplitude characteristics.

From authors' summary

4429. Gusev, L. A., Determination of periodic behavior of automatic control systems containing a nonlinear element with broken-line characteristics, *Automation and Remote Control* **19**, 10, 911–925, June 1959. (Translation of *Avtomatika i Telemekhanika, USSR* **19**, 10, 931–944, Oct. 1958 by Instrument Society of America, Pittsburgh, Pa.)

4430. Shirokorad, B. V., Concerning the existence of a cycle beyond the absolute stability conditions of a three-dimensional system, *Automation and Remote Control* **19**, 10, 933–947, June 1959. (Translation of *Avtomatika i Telemekhanika* **19**, 10, 953–967, Oct. 1958 by Instrument Society of America, Pittsburgh, Pa.)

Beyond the absolute stability conditions [Cf. A. I. Lur'e, "Some nonlinear problems in the theory of automatic control" (in Russian), Gostekhizdat, Moscow, 1955] of a closed-loop system with a neutral object and a regulator having a nonlinear speed of control reset, there always exists a nontrivial (in particular, periodic) stable regime. Physical interpretations of the system are presented.

From author's summary by H. D. Block, USA

4431. Tikhonov, V. I., Fluctuation action in the simplest parametric systems, *Automation and Remote Control* **19**, 8, 705–711, May 1959. (Translation of *Avtomatika i Telemekhanika, USSR* **19**, 8, 717–724, Aug. 1958 by Instrument Society of America, Pittsburgh, Pa.)

The problem of the action of random signals in nonlinear systems can sometimes be successfully reduced to the solution of the differential equation

$$y_t + \xi(t)\, y = \eta(t),$$

where $\xi(t)$ and $\eta(t)$ are random functions. Assuming that these functions are correlated, stationary and normal, with known characteristics, a special method of solution is derived, in which the form of the results permits a significant simplification in the calculation of statistical characteristics of the output $y(t)$, which is subsequently carried out. The application of this method is shown on three examples calculated in detail: (1) First-order, linear, differential equation with random external force, i.e. a special case of the above equation with zero initial conditions and $\xi(t) \equiv$ const. (2) Special case with $\eta(t) \equiv 0$. (3) Special case with zero initial conditions and noncorrelated random functions $\xi(t)$, $\eta(t)$, which has been investigated under certain special assumptions concerning the function $\eta(t)$ in papers by Rosenblom-Heilfron-Trautman and by Zadeh, quoted in references.

Z. Rezny, Czechoslovakia

4432. Ryabov, B. O., Determination of the parameters of a system of self-induced vibrations of some servomechanisms with a three-positional symmetrical characteristic of the nonlinear element (in Russian) *Avtomatika, Akad. Nauk URSR* no. 3, 49–55, 1957; *Ref. Zh. Mekh.* no. 2, 1959, Rev. 1174.

The author communicates the results of his previous investigations of autovibrations in a servo-system, the relay element of which possesses hysteresis and a zone of insensitivity. A method is given for finding the parameters of the autovibrations with a relay element as described and a comparison is made with the author's previous investigations. The extension of the method consists in widening the conditions for the supply of solutions of systems of differential equations corresponding to the zones of the relay characteristic.

G. M. Ulanov

Courtesy Referativnyi Zhurnal, USSR

4433. Sundstrom, M., Spectral methods for the study of servocircuits defined by linear differential equations with stochastic coefficients, Roy. Inst. Technol., Stockholm, KTH Aero TN 48, 11 pp., 1958.

Purpose of report is to generalize some of author's earlier results [Sundström, M., and Flodin, K., KTH AERO TN 44, 1957] on output spectral densities of linear, time-varying systems to systems with time-varying, stochastic coefficients. Result is an integral equation for output spectral densities. Little hope is raised for being able to solve this general equation. Author suggests possibility of breaking up frequency range into sections, in each of which the kernel is nearly constant. Of course, such a process, as well as being unsatisfactory theoretically, can be exceedingly complicated, particularly for wide band systems. Author then attempts to compute approximate spectral densities for small time intervals. Result is still—as author admits—very complicated. Reviewer believes equally accurate and computationally

simpler results could be obtained for the case of small time intervals by the obvious procedure of approximating the coefficients over short time intervals by time-invariant (but still stochastic) coefficients. M. Shinbrot, USA

4434. Pinsker, I. Sh., The design of a plotter by successive compensation (in Russian), *Trudl Seminara po Technosti Mechanizmov i Mashin. In-ta Mashinoved. Akad. Nauk SSSR* no. 7, 3–38, 1954; *Ref. Zh. Mekh.* no. 8, 1958, Rev. 8422.

The author designates as a plotter any system (electrical, mechanical, etc.) to the input of which arguments $x_1, \ldots, x_n$ are applied, while the output furnishes a given function, $z = z(x_1, \ldots, x_n)$. A method of interpolation is suggested for the synthesis of plotter systems with low structural error. Examples of systems reproducing functions of two variables are analyzed; in particular, mechanical arrangements (differential gears, hinged sevenfold linkages, decade multipliers) and electrical circuits. The case of three variables is briefly considered. In conclusion it is pointed out that the method can also be used in the selection of empirical formulas and for the construction of some types of nomograms. M. A. Aizerman

Courtesy Referativnyi Zhurnal, USSR

4435. Sefl, O., On stability of a randomized linear system (*in English*), *Scientia Sinica* **7**, 10, 1027–1034, Oct. 1958.

4436. Tsypkin, Ia. Z., Sampled-data systems with extrapolating devices, *Automation and Remote Control* **19**, 5, 383–394, Mar. 1959. (Translated from *Avtomatika i Telemekhanika, USSR* **19**, 5, 389–400, May 1958 by Instrument Society of America, Pittsburgh, Pa.)

This paper is concerned with the characterization of an extrapolating device which follows a data-sampling element. The output of the sampling element is transformed by the extrapolator into a continuous quantity between sampling times according to a definite law. This law is taken to be a polynomial in time. The coefficients of the polynomial change from interval to interval. Taylor's series, Newton's formula and the method of least squares are discussed. Equations for closed-loop sample-data systems with extrapolating devices are derived and various methods given for presenting the transfer functions of open loop systems. The paper concludes with a helpful, illustrative example involving Nyquist plots. R. Oldenburger, USA

4437. Berkman, B. A., Evaluation of nonlinearity in the return linkage of a system of control for a hydroturbine (in Russian), *Energomashinostroenie* no. 2, 8–11, 1958; *Ref. Zh. Mekh.* no. 2, 1959, Rev. 1180.

A concrete system of automatic control for a hydroturbine is investigated. When the vibrations are small the system can be described by means of differential equations, which can be distinguished by their taking into account dry friction in the cable transmission of the return link. The autovibrating regimes are determined by the method of harmonic balance. M. A. Aizerman

Courtesy Referativnyi Zhurnal, USSR

4438. Ermakov, S. S., and Esipovich, E. M., A way of forming transfer functions of sampled-data control systems with extrapolating devices, *Automation and Remote Control* **19**, 5, 395–401, Mar. 1959. (Translation of *Avtomatika i Telemekhanika, USSR* **19**, 5, 401–407, May 1958 by Instrument Society of America, Pittsburgh, Pa.)

This paper deals with closed-loop sampled-data systems, where the sampler is followed by an extrapolator for digital to analog conversion. The present work gives a method of forming transfer functions for extrapolating devices which permit the application of well-known sampled-data control theory to the analysis and synthesis of systems containing these extrapolators. Linear extrapolation is treated, and the Laplace transform employed. The paper includes a helpful table of formulas relating the output variable of a linear extrapolating device to the discrete values of the input variable, as well as to the corresponding conditional transfer function. R. Oldenburger, USA

4439. Chien, S., Synthesis of the control unit of a servosystem optimum from the point of view of speed of response, *Automation and Remote Control* **20**, 3, 261–275, Jan. 1960. (Translation of *Avtomatika i Telemekanika, USSR* **20**, 3, 273–288, Mar. 1959 by Instrument Society of America, Pittsburgh 22, Pa.)

The switching surface for a servosystem which is optimum from the point of view of speed of response is determined. The system possesses second-order astatism and is described by a third-order differential equation. Approximations to this surface are carried out, and a control unit which provides almost optimum transient processes in the system is designed. Results of the experimental investigation of a system with an electronic model of the member are given. From author's summary

4440. Perov, V. P., Concerning the realization of optimum weighting functions of pulse servosystems, *Automation and Remote Control* **20**, 3, 276–284, Jan. 1960. (Translation of *Avtomatika i Telemekanika, USSR* **20**, 3, 289–297, Mar. 1959 by Instrument Society of America, Pittsburgh 22, Pa.)

Simple techniques for the approximate realization of optimum weighting functions of pulse servosystems are given for several particular cases. From author's summary

4441. Morosanov, I. S., Methods of extremal control (in Russian), *Avtomatika i Telemekhanika* **18**, 11, 1029–1044, 1957; *Ref. Zh. Mekh.* no. 2, 1959, Rev. 1177.

Paper is devoted to consideration of extremal regulators, i.e. regulators of a new type which have appeared in the last few years and are intended for use in the automatic finding and maintaining regimes of work of objects being controlled, where any parameter attains maximum and minimum values. The first two paragraphs deal with the classification of regulators of this type. The classification proposed by other authors is dealt with briefly, the author's own in more detail. In the latter the basis of the scheme is the subdivision of the systems of extremal control according to the method of search adopted to find the extreme, followed by a further subdivision based on the principle of action involved. The author is of the opinion that the calculation of the relay systems in extremal control can be carried out by methods customarily used in the theory of relay systems. M. A. Aizerman

Courtesy Referativnyi Zhurnal, USSR

4442. Assadourian, A., and Cheatham, D. C., Longitudinal range control during the atmospheric phase of a manned satellite reentry, NASA TN D-253, 46 pp., May 1960.

The feasibility of guiding a manned satellite to some preselected destination, by making use of the pilot to control the trajectory, has been demonstrated. A fixed cockpit coupled with an analog computer simulated a high-drag variable-lift class of reentry vehicle. Two control methods were investigated, one making use of typical ground-controlled approach procedures and the other making use of onboard navigational aids. Terminal range errors of the order of ±20 miles were possible for a wide range of conditions. From authors' summary

4443. Eterman, I. I., Mathematical problems associated with the automatic control of a milling machine, *Automation and Remote Control* **20**, 3, 285–290, Jan. 1960. (Translation of *Avto-*

matika i Telemekanika, USSR **20,** 3, 298–303, Mar. 1959 by Instrument Society of America, Pittsburgh 22, Pa.)

Mathematical problems arising in the automatic control of a milling machine by means of a digital computer are considered. The machine's structure and parameters are analyzed. Formulas are given for the processing of data for conversion into control pulses. From author's summary

4444. Zalmanzon, L. A., and Semikova, A. I., Investigation of the characteristics of pneumatic jet elements, *Automation and Remote Control* **20,** 4, 431–448, Jan. 1960. (Translation of *Avtomatika i Telemekhanika, USSR* **20,** 4, 447–467, Apr. 1959 by Instrument Society of America, Pittsburgh 22, Pa.)

Article deals with an investigation of pneumatic jet elements, the operation of which is based on the utilization of the characteristics of pressure changes obtained when the impact tube is moved through different sections of the jet flowing from a nozzle. Examples are given of the possible applications of such elements in pneumatic devices. From authors' summary

4445. Draper, C. S., Wrigley, W., and Woodbury, R. B., Principles of inertial guidance, Advances in Aeronautical Sciences, Vol. 1 (Proc. of the First International Congress in the Aeronautical Sciences, Madrid, Sept. 8–13, 1958), Pergamon Press, 1959, 524–562.

4446. Baranchuk, E. I., Analysis of the stability of linearly combined controlled and tracking systems (in Russian), *Trudi Leningrad Voen.-Mekh. In-ta* no. 6, 316–334, 1957; *Ref. Zh. Mekh.* no. 2, 1959, Rev. 1154.

An investigation is made of a combined system of automatic control consisting of several linear systems joined by means of intersecting linkages. A method is proposed which sometimes simplifies the examination of the stability of systems of this type. A. N. Krylov's conversion is brought into use for this purpose; this conversion changes all the diagonal elements of the characteristic determinant into elements of one column. Adequate conditions of stability are proposed for the characteristic determinant converted in this manner and for some special classes of interconnected systems. M. A. Aizerman

Courtesy Referativnyi Zhurnal, USSR

4447. Stewart, E. C., and Smith, G. L., The synthesis of optimum homing missile guidance systems with statistical inputs, NASA Memo 2-13-59A, 57 pp., Apr. 1959.

4448. Safonova, E. V., The principal moment of forces acting on a spherical gyroscope from the side of the rotor (in Russian), Theory and design of parts in precision mechanics, Moscow-Leningrad, Mashgiz, 1957, 39–54; *Ref. Zh. Mekh.* no. 2, 1959, Rev. 1141.

The electrodynamic forces are examined which act on a spherical gyroscope controlled by the interaction of the magnetic field of the stator and the eddying currents of the rotor. Making use of the equations for electrodynamics in their application to the given case the author arrives at final expressions for the moments of electrodynamic forces acting on the sphere. Clear expressions are given for the corresponding coefficients of proportionability by means of the physical properties of the system.

V. N. Koshlyakov

Courtesy Referativnyi Zhurnal, USSR

4449. Danilin, V. P., Defects in the cardan setting of gyro horizons (in Russian), *Trudi Mosk. Aviats. In-ta* no. 84, 5–10, 1957; *Ref. Zh. Mekh.* no. 2, 1959, Rev. 1142.

The defects are investigated of a gyro horizon, which are produced because of the kinematics of the cardan suspension in two variants: (1) the axis of the external frame coincides with the transverse axis of the airplane; (2) the axis of the external frame is parallel to the longitudinal axis of the airplane. For both cases, formulas are derived for the cardan's errors in determining the angles of banking and soaring. Author reaches the known conclusion that in the case of the second variant there is no error when the position of the axis of the figure is vertical. There are no references to published works dealing with this question.

V. N. Koshlyakov

Courtesy Referativnyi Zhurnal, USSR

Tables, Charts, Dictionaries, etc.

(See Rev. 4623)

Elasticity

(See also Revs. 4403, 4421, 4466, 4469, 4471, 4474, 4480, 4488, 4494, 4512, 4524, 4533, 4535, 4546, 4576, 4581, 4615)

4450. Slobodianskii, M. G., General and complete solutions of the equations of elasticity, *Appl. Math. Mech. (Prikl. Mat. Mekh.)* **23,** 3, 666–685, 1959. (Pergamon Press, Inc., 122 E. 55th St., New York 22, N. Y.)

Author discusses theorems on expressing the displacements in terms of three harmonic functions. Consideration is given to the regions in which such expressions are "general" solutions and in which they are "complete" solutions.

B. E. Gatewood, USA

4451. Kharlamova, E. I., A particular case of the integrability of the Euler-Poisson equations, *Soviet Phys.-Doklady* **4,** 2, 313–315, Oct. 1959. (Translation of *Doklady Akad. Nauk SSSR (N.S.)* **125,** 5, 996–998, Mar./Apr. 1959 by Amer. Inst. Phys., Inc., New York, N. Y.)

4452. Uflyand, Ya. S., Three-dimensional problem in the theory of elasticity for an unbounded body with a plane slit (in Russian), *Trudi Leningrad Politekhn. In-ta* no. 192, 60–70, 1958; *Ref. Zh. Mekh.* no. 2, 1959, Rev. 1684.

The stressed state is investigated in an unbounded space with an excision in the form of a semiplane; Green's general problem is solved for the case given, which breaks up into six special cases: for three projections of the force concentrated in a point of the boundary semiplane and their symmetrical or assymetrical disposition in relation to the angular coordinate. The solution is obtained with the aid of integral resolutions and by the use of harmonic functions, possessing special properties on the ridge of the excision. The final formulas are expressed in a closed form.

V. K. Prokopov

Courtesy Referativnyi Zhurnal, USSR

4453. Singer, J., Formulation of the 3-dimensional problem in the theory of elasticity, *Civ. Engng., Lond.* **54,** 640, 1293–1294, Nov. 1959.

4454. Salier, N., The role of the tube thickness and thermal stresses in superheaters of ferritic and austenitic steel (in French), *Rev. Univ. Mines* (9) **15,** 7, 633–649, July 1959.

Author presents a study of the combined effect of pressure and thermal stresses in ferritic and austenitic steel heaters. The analysis employs the fundamental concepts of elasticity theory and plasticity theory, together with thermal hysteresis phenomenon for the technical and economical comparison.

It is general practice to increase the wall thickness of a heater or oven to attain greater strength. This is true if the effects of pressure only are considered. However, if thermal effects are

considered, the author observes that, after a certain value, any further increase in wall thickness actually decreases the life of the heater.

Although austenitic steels are generally considered to be superior to the ferritic varieties with respect to corrosion resistance and weldability and for their excellent performance to elevated temperature, it is pointed out that, for certain applications, the ferritic steels show superior strength.

It is advocated that the nonthermal thickness-diameter criteria for tubes be restudied before their applications to design thermal service. W. T. Daniels, USA

4455. Nowacki, W., Some three-dimensional problems of thermoelasticity, *Appl. Math. Mech. (Prikl. Mat. Mekh.)* **23**, 3, 651–665, 1959. (Pergamon Press, Inc., 122 E. 55th St., New York 22, N. Y.)

Author investigates thermal stresses produced by the action of nonstationary sources of heat arbitrarily distributed in elastic and viscoelastic media. The media used are the infinite space with spherical symmetry and the half-space with axial symmetry. Consideration is given to the construction of Green's functions for the stresses produced by an instantaneous point source of heat.
B. E. Gatewood, USA

4456. Innocenti, P. G., On the calculation of transient and stationary stresses in rotating disks at high temperature (in Italian), *Aerotecnica* **39**, 1, 25–37, Feb. 1959.

Paper concerns the calculation, under some simplifying hypotheses, of the stress state in a rotating elastic disk of variable thickness for a temperature which varies with the disk radius. A detailed study is presented of the functions which appear in the calculation. The functions are then brought to a form suitable for a numerical computer.

When the creep effect is taken into account, author proves the existence of a steady stress state; in such a case, the calculation is performed in a manner similar to that corresponding to the perfectly elastic disk. Numerical applications are included, the results being presented in diagrams.
P. P. Teodorescu, Roumania

4457. Choudhury, P., On the effect of prescribed shearing stress on the plane surface of an elastic slab with varying modulus of rigidity, *Bull. Calcutta Math. Soc.* **51**, 1, 21–24, Mar. 1959.

An infinite elastic layer resting on a rigid foundation is considered. The modulus μ of rigidity of the medium varies exponentially with depth: $\mu = \mu_0 \exp(kz)$. On the upper surface of the layer, $z = 0$, are given the shearing stresses $\tau_{z\theta}$, being a function of r only. Two components of displacement, u_r and u_z, are equal to zero and the third the author obtained from the differential equation (equation of equilibrium):

$$u_\theta = \int_0^\infty \alpha \left[A(\alpha) \exp(\gamma_1 z) + B(\alpha) \exp(\gamma_2 z)\right] J_1(\alpha r)\, d\alpha,$$

where $\gamma_{1,2} = \frac{1}{2}\left[-k \pm (k^2 + 4\alpha^2)^{1/2}\right]$ and $A(\alpha)$, $B(\alpha)$ are arbitrary functions dependent on boundary conditions. Two numerical examples are given. Z. Kaczkowski, Poland

4458. Bakanov, S. A., Torsion of elastic round shafts by means of distributed loads (in Russian), *Izv. Vyssh. Uchebn. Zavedenii. Aviats. Tekhn.* no. 1, 126–132, 1958; *Ref. Zh. Mekh.* no. 2, 1959, Rev. 1697.

An investigation is described of the torsion of a round shaft loaded with a moment and tangential forces distributed over the outer cylindrical surface. By using the semi-inverse Saint-Venant method with the assumption that there are no displacements in the radial direction, and in the z direction, while there are displacements in the θ direction, a differential equation is obtained, analogous to Mitchell's equation which he derived for the calculation of round shafts of variable diameters. The general solution of this equation by Fourier's method is presented in the form of the product of two special solutions $\varphi = F_1(r) F_2(z)$; an expression is obtained for the stress function φ in the form

$$\varphi = r^2 I_2(kir)\, A_n \sin(kz + \alpha_n)$$

where $I(kir)$ is Bessel's function of the first order, A_n, k, α_n are constant magnitudes, r is the fluid radius. After determination of the constants from the boundary conditions on the surface of the shaft and on its ends the final expressions are found for function angle Ψ. It was shown that the radial lines of the transverse sections are somewhat distorted in the deformation process though the sections themselves remain flat. The same method is used for investigating the solutions of the problem of torsion of a hollow shaft, loaded with a moment and tangential forces distributed over the outer or the inner cylindrical surfaces, and a solution is also furnished for the torsional stress in a solid round shaft with two moments applied to its ends. As regards the last problem it was found that the solution coincided with the known solution when making the usual assumptions for the resistance of the materials. A comparison is furnished of the distribution of the tangential stresses on the shaft's axis, obtained from the analytical calculations, with the experimental data. The distributed load due to tangential forces is reproduced on the grooved connections in the form of two costressed grooved shafts made of an aluminum alloy (the number of grooves $Z = 16$, the length of the grooves = 60 mm, the radius of the groove $a = 46$ mm). The deformations were measured with wire strain gauges. V. F. Karavanov
Courtesy Referativnyi Zhurnal, USSR

4459. Palotas, L., Torsion of bars with straight axis (in German), *Acta Techn., Acad. Sci. Hungaricae, Budapest* **26**, 1/2, 161–174, 1959.

4460. Penina, N. N., Solution of some contact problems in the theory of elasticity in a bipolar system of coordinates (in Russian), *Trudi Dal'nevost. Politekhn. In-ta* **46**, 9, 1–16, 1957; *Ref. Zh. Mekh.* no. 2, 1959, Rev. 1692.

A precise solution is given for the following plane problem in the theory of elasticity: two hollow cylindrical tubes, made of different material, with sections in the form of an eccentric ring are joined to each other by means of a stressed fitting with an assigned amount of tightness. A determination is required for the stress with the conditions that in the free surface of the inner tube an evenly distributed radial pressure shall be applied, while the outer surface shall be free of force action. The author was able to show, by solving the problem in a bipolar system of coordinates, that an exact solution of the problem in question can be obtained with the aid of the final sum-total of the special solutions of the biharmonic equation, that is, that for each of the two regions under observation it is sufficient to take four such solutions which leads, generally speaking, to a system of eight linear algebraical equations. The solution obtained can be extended to embrace the case where the load is applied to the outer surface. A degenerate case is also examined where the external tube is transferred to a semispace with a boundary parallel to a cylindrical channel. Numerical calculations are carried out and graphs are produced of the stresses for some values of the parameters.
Ya. S. Uflyand
Courtesy Referativnyi Zhurnal, USSR

4461. Romalis, B. L., Pressure distribution in internally contacting resilient circular cylinders (in Russian), *Vestnik Mash.* **38**, 12, 13–15, 1958.

Starting from theoretical equations given by I. J. Staerman (1949) author shows that it is possible to get the pressure distribution in

contact area between a pin and its bushing as an analytical function of angle. This function is determined for a steel pin, and steel, iron, and brass bushings, by two first terms of a Fourier series

$$\rho(\varphi) = a_1 \cos \frac{\pi \varphi}{2\varphi_0} + a_3 \cos \frac{3\pi\varphi}{2\varphi_0},$$

φ_0 being the contact angle. Graphical representation of results obtained in this way shows that there is good agreement with the theoretical results computed by direct numerical solution of Staerman's equations. Z. Horak, Czechoslovakia

4462. Vorovich, I. I., and Ustinov, Iu. A., Pressure of a die on an elastic layer of finite thickness, *Appl. Math. Mech. (Prikl. Mat. Mekh.)* **23**, 3, 637–650, 1959. (Pergamon Press, Inc., 122 E. 55th St., New York 22, N. Y.)

The surface of contact between the die and the layer in cylindrical coordinates is assumed to be $z = \phi(\rho)$, z axis being the axis of the die. The conditions of contact give rise to dual integral equations the solution of which leads to the determination of $q(\rho)$, the pressure function of the die on layer of thichness b. The problem is then reduced to Fredholm integrals which permit numerical integration by successive approximation. Two cases are considered: (a) The case of a plane die when $\phi(\rho) = 0$. Formulas have been derived, showing good approximation, for force of penetration for $b > 1.5$, and for stress $q(\rho)$ under the die for $b > 1.7$. (b) The case of a parabolic die when $\phi(\rho) = (\rho^2/2R)$. Formulas are derived and plot is made to show dependance of $q(\rho)$ on thickness. D. N. Mitra, India

Viscoelasticity

(See also Revs. 4455, 4456, 4469, 4474, 4546, 4598, 4932)

4463. Goldhoff, R. M., Comparison of parameter methods for extrapolating high-temperature data, *ASME Trans.* **81** D (*J. Basic Engng.*), 4, 629–644, Dec. 1959.

Equations for predicting stress-rupture characteristics of materials are analyzed to provide designers with specific parameters for practical use. Experimental data used are from alloys S-590, A-286, Nimonic 80A, and 1 Cr – 1 Mo – 1/4 V steel. Author points out limitations of extrapolation, and shows greater accuracy by using parameters derived from minimum experimental deviations. The parametric forms evaluated are those of Larson-Miller, Dorn, and Manson-Haferd, the latter giving superior results for the data studied. Useful discussion by Mendelson and Manson gives further statistical evaluation of the various forms.

H. I. Fusfeld, USA

4464. Zamo, W. A., Lang, D. D., and Brotzen, F. R., Steady-state creep of tin near the melting point, *J. Mech. Phys. Solids* **8**, 1, 45–51, Jan. 1960.

The steady-state creep rates of commercial tin were investigated at temperatures between 180 and 230°C. Torsional creep equipment was developed for this purpose. At temperatures below 215°C results indicate that the steady-state creep process is governed by a single activation energy of 22,500 cal/mole. At higher temperatures, however, the simple Arrhenius-type equation cannot properly express the creep behavior.

From authors' summary

4465. Conrad, H., Correlation of high temperature creep and rupture data, *ASME Trans.* **81** D (*J. Basic Engng.*), 4, 617–628, Dec. 1959.

Author compares various forms of creep rate equations of the family:

$$\dot{\varepsilon} = f(\sigma, T, s) \exp -(\Delta H_0/RT)$$

He shows correlation with experimental data is best described for high temperature creep over a wide stress range when the function f is taken as

$$f = A(s) \sinh [\sigma/\sigma_0(T)]^n$$

where the structure factor $A(s)$ can be considered approximately constant. This has thus far no theoretical foundation from dislocation theory, which predicts a function for low stress values of

$$f = A\sigma^n/T \qquad (n \sim 4)$$

H. I. Fusfeld, USA

4466. Bors, C. I., Torsion of composite orthotropic bars and the creep effect (in Roumanian), *Studii si Cercetari Stint. Mat.* **10**, 1, 157–164, 1959.

Paper concerns the torsion of a bar consisting of several parallel cylindrical rods laterally welded to a surrounding body. The exterior lateral surface is a cylinder the generatrices of which are parallel to the rods. Each intervening medium verifies a rheological equation of state corresponding to an orthotropic body. Author shows the manner in which various geometrical and mechanical magnitudes may be obtained by using a stress function, and meanwhile generalizes R. Bredt's formula.

An application is given to a bar the cross section of which consists of two rectangular regions having a common side.

P. P. Teodorescu, Roumania

4467. Neville, A. M., Recovery of creep and observations on the mechanism of creep of concrete, *Appl. Scient. Res. (A)* **9**, 1, 71–84, 1959.

Test data on the recovery of creep of mortar specimens made with different cements are presented. It is shown that, whereas creep depends on the strength of mortar (as influenced by the cement), the creep recovery is not a function of this strength. From measurements on the change in weight of specimens, under load and free-standing, it is concluded that creep is not caused by the movement of water from the cement paste into the surrounding medium. The possibility of creep being connected with the removal of zeolitic water from calcium silicate hydrates is discussed, and reasons for the nonreversible character of creep recovery are suggested. From author's summary

Plasticity

(See also Revs. 4463, 4465, 4476, 4551, 4552, 4582, 4595, 4935, 4964)

4468. Nakanishi, F., and Sato, Y., Influence of intermediate principal stress on plastic flow, *Bull. JSME* **3**, 9, 54–59, Feb. 1960.

Paper forms part of a series of investigation concerning a plasticity theory recently proposed by the author, based on the viewpoint that plastic deformation is composed of shears in three mutually orthogonal directions, considered individually. In this paper, it is deduced from the theory that the flow condition is given by two straight lines intersecting at $\sigma_1 = 4\sigma_2$ for the stress states between tension $\sigma_2 = 0$ and pure shear $\sigma_2 = \frac{1}{2}\sigma_1$, σ_3 being zero, and accordingly that the ellipse representing Mises' yield locus in the σ_1, σ_2 plane is replaced by a dodecagon. The abrupt bending of flow condition is ascertained by experiments of yielding of circular tubes under stress states of combined axial tension and internal pressure, and some other experiments. Reviewer has not come to full understanding as yet of the basic ideas of this theory, though it seems suggestive.

Y. Yoshimura, Japan

4469. Nakagawa, Y., Yield point depends on the rate of strain; its theory, *Bull. JSME* **2,** 8, 501–503, Nov. 1959.

The dynamic modulus of elasticity of a substance may differ from the static modulus, and the yield stress varies with rate of strain. In order to explain these facts, author assumes a model which consists of two springs, two dashpots, and a set of friction blocks. (The friction blocks are fitted with each other on their plane surfaces and are pressed by a spring.) These elements are so arranged that the spring of a Voigt model is connected in series to the dashpot of the other Voigt model and the set of friction blocks, which are parallel with each other.

A simple mechanical consideration yields two equations: [1] $\sigma = D + 2B\dot{\varepsilon}$, and [2] $\sigma = 2E\varepsilon - D$. Here σ is the applied stress; ε is the shear on the spring; $\dot{\varepsilon}$, the shear rate on the dashpot; E the elasticity constant of the spring; D the force on the friction blocks; and B the viscosity of the dashpot. Author applies Eqs. [1] and [2] to the cases where the shear rate is constant, is very large, and is very small. He explains the aforementioned experimental facts successfully. He also explains the curves of microstrain versus time for the tension test on 0.112% carbon steel, and also strain-hardening curves in general.

H. Eyring, USA

4470. Eason, G., The load-carrying capacities of cylindrical shells subjected to a ring of force, *J. Mech. Phys. Solids* **7,** 3, 169–181, June 1959.

A thin cylindrical shell of finite length and free ends subjected to an arbitrarily placed ring of force is considered. The material is assumed to be rigid perfectly plastic for which the yield criterion in terms of the stress resultants has been formulated by D. C. Drucker [AMR **7** (1954), Rev. 2470]. The collapse loads are found by direct integration of the shell equations using the exact yield criterion. Five modes of collapse are found to exist, depending on the location of the ring of force; collapse loads are calculated for all shell lengths.

E. H. Dill, USA

4471. Walsh, J. B., and MacKenzie, A. C., Elastic-plastic torsion of a circumferentially notched bar, *J. Mech. Phys. Solids* **7,** 4, 247–257, Oct. 1959.

A cylindrical bar is investigated. A notch of finite root radius is depicted and attention is centered initially on the case of the infinitely sharp notch. The analysis is discussed in three sections, concerned with the determination of (1) a relationship between applied torque and extent of plastic region, (2) angle of twist over a suitable gage length, and (3) plastic strains in the plane of the notch. Formulas are given for the fully plastic torque and for the plastic zone radius that is independent of the notch depth. Angle of twist (elastic region) and plastic strains are calculated and curves are given for plastic zone length and angle of twist.

Experimental study was to obtain torque–twist curves and measure notch root surface strains. The specimens were 7075-T6 aluminum-alloy bars. Electric resistance strain-gage elements were incorporated in the torque and angle of twist measuring devices. By using a suitable recorder—in this case a two-channel Sanborn (Carrier Preamplifier)—a continuous, parallel recording of torque and angle of twist was made. Moment-twist and notch-root-strain versus applied-torque curves are given for both the the theoretical and experimental results.

S. Sarkadi Szabo, Hungary

4472. Mendelson, A., and Manson, S. S., Practical solution of plastic deformation problems in elastic-plastic range, NASA TR R-28, 24 pp., 1959.

4473. Brewer, R. C., and Alexander, J. M., A new technique for engraving and measuring grids in experimental plasticity, *J. Mech. Phys. Solids* **8,** 1, 76–78 (Research Note), Jan. 1960.

Rods, Beams and Strings

(See also Revs. 4397, 4403, 4408, 4417, 4421, 4459, 4466, 4471, 4495, 4501, 4518, 4519, 4520, 4521, 4522, 4523, 4524)

4474. Bykoskii, V. N., Investigation of the transverse deflections and components (in Russian), Wooden constructions and components; Derevyan Konstruktsii i Izdeliya, Moscow, Gos. Izd-vo Lit. po Str-vu i Arkhitekt., 1958, 71–89; *Ref. Zh. Mekh.* no. 2, 1959, Rev. 1905.

The transverse deflection of wooden beams under sustained load is investigated from the view-point of the mechanics of elastic-viscous systems. The results of experimental data in the tensioned zone of the beam show that the relation between the stresses and the deformations is expressed linearly; in the compressed zone, in accordance with the exponential principle. By making use of the parity of the applied moment and the moment of internal forces the author evolves a calculation formula which takes into account the velocity of loading of the beam during transverse deflection. Author makes it clear that the results of the investigation appear to be tentative, requiring additional verification.

V. V. Pinadzhyan

Courtesy Referativnyi Zhurnal, USSR

4475. Sung, C.-K., and Tsai, F.-Y., Simplified computations of non-uniform beam constants by the method of complementary I_0/I diagram (in English), *Scientia Sinica* **7,** 11, 1076–1109, Nov. 1958.

4476. Mirolinbov, I. N., An approximate strength analysis of irregularly-stressed bars in the presence of plastic yielding (in Russian), *Trudi Leningrad Voen.-Mekh. In-ta* no. 6, 28–69, 1957; *Ref. Zh. Mekh.* no. 8, 1958, Rev. 9146.

An investigation of the elastic-plastic deformation of bars is based on the assumption that the laws of variation of the displacements are the same in the elastic and the plastic regions. Particular cases are examined of the irregular deformation of bars of circular cross section: torsion, torsional bending, and torsional tension; as well as the case of two-dimensional, transverse flexure of a prismatic bar. A comparison is made between the theoretical results now obtained and the experimental results available in the literature.

N. N. Malinin

Courtesy Referativnyi Zhurnal, USSR

4477. Agent, R., A method for the calculation of beam supported on elastic foundations (in Roumanian), *Rev. Constr. Mater. Constr.* **11,** 9, 449–456, Sept. 1959.

In view of the difficulties encountered by using the stress method for studying continuous beams on elastic supports with unequal settlement rigidities, author employs the displacement method and successive approximations.

In the first calculation step, the rotations of supports are blocked, while their translations are relaxed. In the subsequent calculation step, the displacements of nodes are blocked and their rotations are relaxed. By successively alternating these calculation steps, one may obtain the desired approximation. A numerical example is given.

Finally it is shown that method may be extended to frames.

G. B. Buzdugan, Roumania

4478. Fedulova-Lokkenberg, L. K., Calculations for beams on an elastic foundation with underlying rock strata (in Russian), *Trudi Mosk. In-ta Gorn. Str-va* no. 7, 28–38, 1957; *Ref. Zh. Mekh.* no. 2, 1959, Rev. 1897.

The question is gone into of the application of B. N. Zhemochkin's method ["Calculations for beams on an elastic semi-space and semi-plane," Izd-vo Voenno-inzh. akad. im. V. V. Kuibysheva, 1937]. . . to the calculation of beams on an elastic foundation with

underlying rock. For this purpose the function expressing the basic relation between the load and the settling of the foundation is replaced by another function which takes into account the influence of the absolutely rigid underlying layer. It is shown that after such a replacement and the setting up of a few tables the procedure of calculation for a diversely layered foundation differs in no way from the problem for a homogeneous foundation. A numerical example is given which shows the significant influence exerted by the underlying layer on the magnitude of the deflecting moments and settling of the beam. P. I. Klubin

Courtesy Referativnyi Zhurnal, USSR

4479. Hetenyi, M., A comparison of various solutions for beams on elastic foundations (in English), *Acta Techn., Acad. Sci. Hungaricae, Budapest* **26,** 1/2, 21–28, 1959.

Author compares different solutions of a Winkler-type elastically supported beam of finite length. He explains that the problem has three solutions. The first uses the general solution differential equation, by choosing integration constants in such a way that they fulfill specified limit-conditions in each case. The second approximation utilizes the application of trigonometric series and the principle of virtual work. The third, published by the author in this paper, uses the principle of superposition by loading a beam assumed to be of infinite length in such a way that it is equivalent in its single sections to the investigated beam of finite length. The author points out that each of these three approximations leads to an exact solution of the given problem.

From author's summary

4480. Penzien, J., Discontinuity stresses in beams on elastic foundations, *Proc. Amer. Soc. Civ. Engrs.* **86,** ST4 (*J. Struct. Div.*), 67–93, Apr. 1960.

A method of analysis is presented for obtaining discontinuity stresses in beams on elastic foundation and cylindrical shells subjected to axisymmetrical loading. Also presented are the solutions of numerous basic cases which provide the necessary numerical constants required in the proposed method of analysis. Several examples are included.

From author's summary

4481. Melyakhovetskiy, A. S., The bending of a curvilinear bar loaded in compression due to initial deviations from the correct form (in Russian), *Trudi Donetsk. Industr. In-ta* **20,** 21–26, 1957; *Ref. Zh. Mekh.* no. 9, 1958, Rev. 10448.

A method is presented for determining the forces and displacements in a compressed curvilinear bar, produced by initial deflections of the elastic axis from the catenary curve for the given external load (X_0, Z_0). Proof is previously given of the theorem of unique resolution of any applied external load (X_0, Z_0) into partial loads, one of which (X_1, Z_1) produces in the unstrained bar only compression stresses and the other (X_2, Z_2) only bending moments and shearing forces. The equivalent load of the initial bending deflection, which, when in the correct form, causes only shearing forces and bending moments in the bar, is determined; and approximations are given for determining the displacements and bending moment. Yu. S. Shkenev

Courtesy Referativnyi Zhurnal, USSR

4482. Malikov, G. F., The calculation of beams with a large bending deflection by the method of limiting equilibrium (in Russian), *Trudi Mosk. Energ. In-ta* no. 29, 5–18, 1957; *Ref. Zh. Mekh.* no. 9, 1958, Rev. 10353.

4483. Guiaux, P., Welded composite beams under torsional loads (in French), *Rev. Soudure* **15,** 2, 61–81, 1959.

Wide-flanged steel beams with horizontal stiffener at mid-depth have been subjected to combined bending and twisting movements. The rupture stress was found to be between that estimated by the theories of Tresca-Saint Venant and Mises-Hencky.

G. G. Meyerhof, Canada

4484. Polozhii, G. M., and Skorobogat'ko, A. A., Determination of the stresses in cylindrical shafts pierced with a circular recess (in Russian), Mekh.-Mat. Fak. Kievsk. In-ta 1956; Kiev, 1957, 534–535; *Ref. Zh. Mekh.* no. 2, 1959, Rev. 1701.

The following case is investigated: an infinite cylindrical shaft with a radius R, subjected to torsion by an over-all moment M, with a recess on its lateral side hyperbolic in shape, the depth of the recess being α and the width 2β; the lateral surface of the shaft is free from external forces. By making use of G. M. Polozhii's method [*Izv. Akad. Nauk SSSR, Ser. Mat.* **19,** 3, 245–270, 1955] authors are able to give a high and a low estimate for the approximate solution for the problem in the work referred to, which estimates, as re-calculations showed, with $\alpha > R/2$ gave an error not exceeding 3–6% and with $\beta > R - \alpha$ not exceeding 3–1%. As a result of these estimates it is noted that if the circular recess of hyperbolic form degenerates into a circular slot the stresses near the bottom of the recess will become infinite.

V. I. Tul'chii

Courtesy Referativnyi Zhurnal, USSR

Plates, Shells and Membranes

(See also Revs. 4421, 4454, 4470, 4510, 4512, 4513, 4575)

4485. Klyushinkov, V. D., Method of approximate calculation of bending of elastically clamped plates of arbitrary contour (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 9, 126–129, Sept. 1957.

Author proposes an approximate procedure for solving problems of bending of plates with arbitrary contours. Since the choice of deflection functions in variational methods is very difficult, author examines the horizontal lines (lines of constant deflection) of the deformed plate. Expressions for bending moments and shear forces are given for an arbitrary horizontal line; it is shown that in the case of elastic clamping the boundary conditions can be satisfied approximately. W. Nowacki, Poland

4486. Levina, Z. M., and Reshetov, D. N., Calculation and experimental investigation in flexion of complex circular plates with radial and annular ribbing (in Russian), *Vestnik Mash.* **39,** 2, 8–11, Feb. 1959.

Deflected surfaces for box-type plates, loaded by central concentrated force, have been evaluated by Ritz-Timoshenko method. Energy of shear deformation in ribs has been taken into account. Experimentally obtained deflections of plastics models have been compared with the calculated values, satisfactory agreement being pointed out. For practical calculations of face plates in machine design the authors recommend replacing sandwich plate rigidity D by the D_{red}, accounting for shear stiffness of radial ribs. The reduced rigidity is given as $D_{red} = D/1 + k$, $k = 4\pi D(1, 2 + \mu)/GnFr$, where F is cross-section area of a radial rib, n number of ribs, r radius of the plate, G and μ elastic constants.

A. Sawczuk, Poland

4487. Ambartsumyan, S. A., On the theory of bending of anisotropic plates (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 5, 69–77, May 1958.

Author derives the displacement equations for an anisotropic plate of constant thickness, under the following assumptions: (a) the stresses δ_y normal to the middle surface are negligible in comparison to other stresses, (b) the distance along the normal (y) between two points is unaltered by the deformation, and (c) the

tangential stresses $\tau_{\alpha\gamma}$ and $\tau_{\beta\gamma}$ vary along the thickness in accordance with the law

$$\tau_{\alpha\gamma} = f(\gamma)\,\varphi(\alpha, \beta), \qquad \tau_{\beta\gamma} = f(\gamma)\,\psi(\alpha, \beta)$$

where $f(\gamma)$ is a given function, and φ, ψ are unknown. Expressing the displacements u_α u_β by $u_\gamma = w(\alpha, \beta)$, introducing moments and shear forces and making use of the equilibrium equations the author derives a system of three differential equations with the unknowns w, φ, ψ. This system can be reduced to one equation of sixth order. The function $f(\gamma)$ is assumed to be a parabola of second degree, vanishing on the surfaces bounding the plate; it is proved that deviations from this form have only small influence on the final results. W. Nowacki, Poland

4488. Tamate, O., Further studies on the influence of an infinite row of holes on the transverse flexure of a thin plate, *Technol. Rep. Tohoku Univ.* **22,** 1, 41–50, 1957.

The problem of determining the deflection and stresses in an infinite plate containing an infinite row of equal and equally spaced circular holes under the state of cylindrical bending about the line of centers is considered by use of the Poisson-Kirchoff theory of thin plates.

Biharmonic functions having infinities at the points $x = pb$, $y = 0$, p being any integer or zero, and periodic in x with period b (distance between centers of holes) are introduced to satisfy given boundary conditions on the circle $r = a$ ($a < b$). They will then satisfy identical conditions on all the circles of radius a with their centers at $(pb, 0)$.

The boundary conditions lead to an infinite set of linear equations. These are solved by a method of successive approximation, which is proved to be convergent if $a/b < 0.35$.

Numerical calculations are also carried out.

From author's summary by P. G. Shuleshko, USA

4489. Shtaerman, M. I., Calculations for elastic rectangular plates set in an elastic frame (in Russian), Nauchn. Soobshch. Vses. N.-i. In-ta VNII-STROINEFT', Moscow, 1957, 27 pp.; *Ref. Zh. Mekh.* no. 2, 1959, Rev. 1738.

Calculations are made using ordinates of trigonometrical series; the ordinary boundary conditions for the plate are supplemented by conditions in the angles. The problem merges with an infinite system of linear algebraical equations, derived in a manner which speeds up the convergence of the process of calculation. In the example given the author was able to show that a high standard of accuracy is obtained by a sufficient delimitation of the number of terms in the series. E. I. Grigolyuk

Courtesy Referativnyi Zhurnal, USSR

4490. Johns, D. J., Discontinuity stresses in stiffened cylindrical shells—the determination of stresses due to pressure and thermal effects in certain classes of stiffened cylindrical shells, *Aircr. Engng.* **31,** 363, 131–132, May 1959.

An approach is presented to the calculation of discontinuity stresses for pressurized and heated uniform cylindrical shells stiffened by plane bulkheads. The shells are assumed to be at uniform temperatures and maintained at different internal pressures. The bulkhead is subjected to an arbitrary radial temperature distribution with linear variation of temperature between the faces of the bulkhead. Using linear theory of thin cylindrical shells and plates, author derives the formulas for edge moments and shears. Modifications to the analysis have been suggested to allow for other forms of stiffening.

One obvious application for this analysis is the fuselage structure of a ballistic missile. An analogous problem concerning heat exchangers was solved by Y.-Y. Yu [*J. Appl. Mech.* **23,** 3, 468–473, Sept. 1956]. C. Hoschl, Czechoslovakia

4491. Remizova, N. I., Integral equations of equilibrium of thin elastic cylindrical shells, *Appl. Math. Mech. (Prikl. Mat. Mekh.)* **23,** 3, 872–879, 1959. (Pergamon Press, Inc., 122 E. 55th St., New York 22, N. Y.)

Author considers a cylindrical shell of continuous medium and of constant thickness and obtains the integrodifferential equations of equilibrium using the theorem of Betti. Besides the prescribed forces and sought displacements a system of auxiliary forces and auxiliary displacements is now needed. Author derives such a system by first rolling out the shell into a plate. She shows that the most suitable auxiliary system is the one derived from the solution of the problem of the plate under the action of a concentrated unit force with boundary conditions which are identical to those of the shell. Also the case where the above plate problem is difficult to solve is treated. Finally the author considers, as an example, a circular cylindrical shell acted upon by a concentrated normal force and hinged along its edges, concluding from the calculations that, in general, if, in setting up the differential and integral equations for the equilibrium of one and the same shell, one starts from the same assumptions, then the two sets of results are identical. O. B. Hellman, Denmark

4492. Olszak, W., and Sawczuk, A., Ultimate load-carrying capacity of cylindrical shells for different forms of the yield condition (in German), *Acta Techn., Acad. Sci. Hungaricae, Budapest* **26,** 1/2, 55–77, 1959.

Paper discusses the problems of the limit bearing capacity and plastic flow of orthotropic cylindrical shells with various yield conditions. The difference between the results thus obtained is indicated, particular attention being paid to the fields of internal forces and of the strain velocities, and to the intensity of the ultimate loads, depending on the yield condition and the corresponding limit surface. In addition, a method of linearization of the "quadratic" (Huber-Mises-Hencky) yield condition for cylindrical shells is proposed. The paper also contains some new solutions concerning the limit condition of orthotropic cylindrical tanks. From authors' summary

4493. Lialine, L., Elasticity and strength of tubes under internal pressure (in French), *Rev. Tijdschr.-Mecan. Werk.* **5,** 1, 9–20, 1959.

The tube may be closed at both ends by plugs firmly attached to the ends or it is closed by floating pistons. The well-known formulas for the stresses in the elastic region are given. The critical interal pressure at which plastic deformation starts is given for several yield criteria (Von Mises, Tresca, etc.). The use of such criteria requires knowledge of the yield limit in the tensile test. If the material has not a sharp yield limit the "conventional elasticity limit of 0.01%" is taken as such.

Author concludes from experiments that none of the well-known criteria are valid for thick-walled tubes. Reviewer feels that a yield criterion is a property of a material alone and not of a configuration. In experiments strains were measured at the outer wall of tubes. Even for a material with a sharp yield limit (an ideal plastic material which does not show hardening) the first derivative of these strains with respect to the internal pressure is continuous at the onset of plastic yielding at the inner wall. It is not clear to the reviewer how in the experiments the onset of plastic yielding was detected with desired accuracy. This detection is especially difficult for materials which have no sharp yield limit.

Formulas for the ultimate stress are also given. In deriving these formulas a hardening material is replaced by a nonhardening material. Author discusses also some scale effects.

J. P. Benthem, Holland

4494. Hahn, M. L., Torsion of open cylindrical shells; application to the design of reinforced concrete sheds (in French), *Ann. Inst. Tech. Bât. Trav. Publics* **12**, 138, 575–597, June 1959.

Paper presents an elaborate analysis of the stress and deformation problem of thin-walled open sections subjected to torsional loads, taking into account the stresses due to warping of the cross section. General formulas are derived which may be applied to thin-walled sections of arbitrary shape. Paper concludes with an application to a saw-tooth roof. The agreement between theoretical and experimental values for the deflections is shown to be rather poor. If experimental rather than estimated values for the two elastic constants of concrete had been used in the calculations the agreement might have been better.

J. F. Besseling, Holland

4495. Elpat'evskii, A. N., and Konovalov, B. A., Application of a variational method to the analysis of conical shells (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 8, 106–111, Aug. 1958.

Strains and stresses are considered in a thin-walled slightly tapered beam, with constant wall thickness and arbitrary closed cross section subjected to any external loading. It is assumed that the shell is inextensible in the circumferential direction ($\varepsilon_s = 0$). The circumferential stress-resultant, torsional and longitudinal flexural stress-couples are neglected.

The longitudinal and circumferential displacement components are supposed in the form $u = \Sigma u_i(z)\varphi_i(s)$, $v = \Sigma v_k(z)$ respectively. Functions $\varphi_i(s)$ are assumed to be linear and should be chosen a priori. Functions $u_i(z)$ and $v_k(z)$ are determined by integrating a system of ordinary differential equations with variable coefficients, obtained by applying the principle of virtual work to an element of beam bounded by the cross sections z and $z + dz$.

An example shows that retaining one term only in each of the mentioned series, the known formula of strength of materials is obtained.

A. Kornecki, Israel

4496. Luypaert, P., and Van den Broeck, J., The calculation of ribless ellipsoidal dome-like constructions (in Dutch), *Tech.-Weten. Tijdschr.* **28**, 12, 283–288, Dec. 1959.

Authors deal first of all with the general principles of the calculation of thin shell-like constructions, of which the surface is generated by a plane curve which rotates about a vertical axis in its own plane. The general formulas are then applied to the special case of an ellipsoidal dome generated by the rotation of a half ellipse about its small axis. In these calculations only the actual weight of the construction and the supplementary weight due to snow are taken into consideration. The stresses due to wind force are neglected considering the shape of the surface (broad flat top) and the importance of the own weight of the construction.

From authors' summary

4497. Silkin, E. I., Analysis of shallow shells on an elastic contour (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 8, 101–106, Aug. 1958.

This paper deals with the analysis of two-bay, shallow, dome-shaped shells, stiffened by diaphragms, elastically supported and submitted to the action of uniform vertically distributed load. Both shells are rectangular in plane and have a positive Gaussian curvature. The analysis is based on the fundamental equations of compatibility and equilibrium as developed in Vlasov's monograph "A general theory of shells" (Moscow, 1949).

For the solution of the problem, two auxiliary schemes with the following boundary conditions are studied: (1) Edges of the shells are hinge-supported on diaphragms. Vertical displacement of the shells at the edges as well as the diaphragm itself are excluded. With these conditions the displacement functions are defined. (2) Edges of the shells are supported by the vertically curved flexible diaphragms, allowing torsional effect and vertical displacement, but all corners are fixed.

In this stage the total vertical displacements are expressed as the sum of the displacements under (1) and (2). From these equations the additional displacement of the edges can be found and the displacement W expressed as a trigonometric function of certain parameters. Considering the equilibrium of the infinitely small element of the generatrix of the shell, additional conditions are found for the determination of these parameters.

The analysis resulted in the conclusion that to secure geometric stability, stiffness and greater bearing capacity, it is necessary to provide shells with a positive Gaussian curvature. Diaphragms and supporting edges should possess adequate rigidity in their planes.

M. S. Troitsky, Canada

4498. Galletly, G. D., Influence coefficients for open-crown hemispheres, *ASME Trans.* **82** A (*J. Engng. Power*), 1, 73–81, Jan. 1960.

Stresses and deflections of hemispherical shells with nozzle openings lying on the axis of symmetry may be determined accurately and rapidly with the aid of the tables given in the paper. The tables give the influence coefficients (i.e., stresses and deflections obtained with unit applied loads) for the edge and interior points for various types of edge bending load. The radius-thickness ratios of the hemispherical shells considered varied from 15 to 250; the total central angle of the opening varied from twenty to one hundred degrees.

An illustration of the utility of the coefficients is given by considering a hemisphere-cylinder intersection problem.

From author's summary

4499. Gerard, F. A., The analysis of hyperbolic paraboloidal shell roofs, *Trans. Engng. Inst. Canada* **3**, 1, 32–42, Apr. 1959.

Author analyzes shell roofs of interest in practice. Displacement patterns are assumed and, using energy methods, explicit formulas are derived for deflections, etc. Some numerical examples are given.

Reviewer has discussed subject paper previously. This discussion will shortly appear in the same journal as the author's paper [*Trans. Engng. Inst., Canada*].

G. D. Galletly, USA

Buckling

(See also Revs. 4521, 4575)

4500. Bruzzese, E., Theoretical and experimental investigation of secondary equilibrium configurations of precompressed high beams (in Italian), *Ricerca, Napoli* **9**, 32–50, Jan./June 1958.

A straight concrete beam is prestressed by means of a cable the axis of which is a parabola. The depth of the cross section is large in comparison with the width. There are no external loading forces. In certain cases, if the prestressing force is increased, a critical value of this force is reached at which the plane form of bending becomes unstable, that is, the beam buckles side-wise. This critical value is computed in paper. The instability is due to combined torsion and bending. In order to control the theoretical result, an experimental investigation was carried out. The model was made of a synthetic resin (Perspex); the prestressing component was a steel chord. Agreement between calculated and measured results was rather good (10%).

J. Barta, Hungary

4501. Herrmann, G., and Armenakas, A. E., Shear buckling of bars, AFOSR TN-59-1016 (Columbia Univ., Dept. Civil Engng. & Engng. Mech., Inst. Flight Structures TN-3 CU-7-59-AF-430-CE), 12 pp., Oct. 1959.

Stability equations are derived for an elastic bar of rectangular cross section loaded on its upper and lower surfaces by a uniform shear stress. Solution for the case of a pin-ended bar shows that buckling in the plane of loading will occur when the shear stress exceeds a certain critical value. Authors point out that elastic shear buckling may be difficult to observe in practice because of difficulty in applying pure shear load without hindering lateral displacements and because slenderness ratios of $10^3\pi$ or greater are required for usual engineering materials.

W. E. Jahsman, USA

4502. Radhakrishnan, S., Behaviour of struts with time dependent loads, *J. Aero. Soc. India* **11,** 4, 83–92, Nov. 1959.

Author offers results obtained some time ago for comparison with other solutions of behavior of columns under time-dependent loads. Simply supported column subjected to compressive load varying arbitrarily with time is treated. Analytical solution, in the form of series solution of Mathieu equation, for the case of sinusoidally varying load is given. Stepwise numerical integration of the differential equation for arbitrarily varying loads is proposed.

A. P. Boresi, USA

4503. Mromlinski, R., New buckling theory of rods in plastic region (in Polish), *Inzyn. Budown.* **15,** 7, 223–224, 1958.

4504. Niles, A. S., Beam-columns with elastically restrained ends, *J. Aero/Space Sci.* **27,** 4, 316–317 (Readers' Forum), Apr. 1960.

4505. Gregory, M., The buckling of an equilateral triangular frame in its plane, *Austral. J. Appl. Sci.* **10,** 4, 377–387, Dec. 1959.

An equilateral triangular frame made up of three equal members without causing any internal stresses is considered and, by analogy with single-column theory, its buckling load determined. Next the behavior of a similar frame made up of initially crooked members is observed. It is found that the Southwell plots on strains that occur due to buckling are linear and can be used for finding out the critical load in case of an initially perfect frame. Tests on an experimental frame yielded result that is in good agreement with the calculated load.

A. M. Sengupta, India

4506. Nutt, J. G., The critical load of a triangular framework when lateral buckling occurs, *Appl. Sci. Res. (A)* **8,** 2/3, 169–176, 1959.

The triangular frame is loaded at its joints. Standard tables are used to determine the stiffness and carry-over factors. Combining these factors with the torsional stiffness of the members of the frame, author determines whether the frame is stable or unstable for a given loading. The method is set in matrix form.

E. R. Johnston, USA

4507. Goldberg, J. E., General instability of low framed buildings (in English), *Publ. Int. Assn. Bridge Struct. Engng.* **18,** 15–36, 1958.

4508. Schwertner, A., Buckling of arches (in German), *Acta Techn., Acad. Sci. Hungaricae, Budapest* **26,** 1/2, 175–189, 1959.

Author deduced a new method for static and dynamic calculation of beams and of buckling. The essence of the method is that a beam only loaded at its ends is replaced by an elastic point, and such points are joined in different ways parallel to each other and in series. The present paper dealing with an arch built-in at both ends, completes his preceding papers on the method in question. In his examples author determined the critical load of a test-arch made from spring steel and of a reinforced-concrete arch. It is unfortunate that the results obtained were not confirmed by tests.

From author's summary

4509. Zender, G. W., and Hall, J. B., Jr., Combinations of shear, compressive thermal, and compressive load stresses for the onset of permanent buckles in plates, NASA TN D-384, 26 pp., May 1960.

A semiempirical method of evaluating the onset of permanent buckles in plates is given. The results indicate that the compressive load stress which a plate can support at the onset of permanent buckles is reduced by thermal compressive stresses and by shear stresses. Results of the method are compared with experimental values for the onset of permanent buckles obtained from tests of square tubes of 17-7 PH (Condition TH 1050) stainless steel.

From authors' summary

4510. Anderson, M. S., Optimum proportions of truss-core and web-core sandwich plates loaded in compression, NASA TN D-98, 26 pp., Sept. 1959.

For high-temperature applications where adhesive bonding or brazing is not acceptable, welded forms of sandwich construction are receiving attention. Honeycomb sandwiches not being easily fabricated by welding, author considers "truss" (corrugated sheet) cores and web-cores. Single and double truss cores in section are idealized for analysis into Warren and double Warren trusses. Analytical comparison shows the double-truss core sandwich to be most efficient at high load intensities, the honeycomb sandwich at low load intensities. Web-cores were least efficient at all load intensities. The comparison is for edge compression loading, presumably along the corrugations, although author neither makes this clear nor discusses explicitly any effect of orthotropy.

A. D. Topping, USA

4511. Anderson, M. S., Local instability of the elements of a truss-core sandwich plate, NASA TR R-30, 13 pp., 1959.

See AMR **12**(1959), Rev. 97.

4512. Brush, D. O., and Field, F. A., Buckling of a cylindrical shell under a circumferential band load, *J. Aero/Space Sci.* **26,** 12, 825–830, Dec. 1959.

Infinitesimal theory of buckling is applied to a thin isotropic elastic cylindrical shell of infinite length that is loaded by inward-directed radial pressure distributed on a circumferential band of finite width. In region outside of band there is no load. Positive definiteness of second variation of potential energy is used as stability criterion. Two types of loading are studied: (1) external hydrostatic pressure on loaded band; (2) constriction by a rigid ring, such that pressure is concentrated at high points when buckling occurs. Displacement components are assumed to be representable by few terms of trigonometric series, with coefficients that are functions of axial coordinate. Results are plotted in readily usable form. Comparisons with related calculations of Flügge and Hahne are presented.

H. L. Langhaar, USA

4513. Vol'mir, A. S., and Mineev, V. E., An experimental investigation of the buckling of a shell under dynamic load, *Soviet Phys.-Doklady* **4,** 2, 464–465, Oct. 1959. (Translation of *Doklady Akad. Nauk SSSR (N.S.)* **125,** 5, 1002–1003, Mar./Apr. 1959 by Amer. Inst. Phys., Inc., New York, N. Y.)

Apparatus for subjecting thin cylinders to suddenly applied external pressure is described. Duralumin specimens with radius-thickness ratio of 112 and length-radius ratio of 2.2 failed at pressures 2.7 to 4.0 times the static buckling pressure, with 12 to 50% more circumferential waves, when loaded in 3.3 to 1.6 milliseconds.

L. H. Donnell, USA

Vibrations of Solids

(See also Revs. 4396, 4415, 4421, 4559, 4876, 4952)

4514. Odqvist, F. K. G., Dunkerley's approximate formula and similar formulas for the eigenvalues of vibration problems (in German), *Ing.-Arch.* **28,** 242–245, Mar. 1959.

Author describes an approximate method of solution of the frequency determinant associated with the small vibration of n masses and demonstrates that the solution of the characteristic equation of the system can be solved approximately with sufficient accuracy if the roots possess sufficiently distinct values. The first approximation given contains Dunkerley's and Southwell's solutions. The second approximate solution, a generalized Hahn's solution, gives a correction for the largest as well as for the smallest roots, assuming that such corrections actually do exist (excluding imaginary roots).

The method serves, in any case, as a good initial approximation for an exact evaluation of the eigenvalues for small vibration by standard methods.

The results should be of considerable interest to practicing engineers. G. AE. Oravas, Canada

4515. Kazak, S. A., The nature of the oscillations of a load on a suspension of variable length (in Russian), *Sb. Statey Ural'skogo Politekhn. In-ta* no. 56, 15–19, 1955; *Ref. Zh. Mekh.* no. 8, 1958, Rev. 8401.

The problem examined concerns the oscillations of a load suspended on a flexible rope with varying length of suspension. Applying particular assumptions, this problem can be reduced to the problem of the motion of a mathematical pendulum, the equation of which is represented by

$$\dot{l}\theta + 2\ddot{l}\theta + g\theta = 0 \qquad [1]$$

where l is the length of the pendulum; θ the angle of deflection from the vertical, g the acceleration of gravity, considered qualitatively. By finding the conditions in which Eq. [1] can be represented in complete differentials, and when it has a fluctuating solution, author arrives at the following conclusions: If the length of the suspension is increased at an acceleration of $\ddot{l} \geq g$, the motion of the pendulum will be limitational; if $g > \ddot{l} > 0$, the motion of the pendulum will be oscillatory about the vertical, and fading. If the length of suspension is shortened, under any conditions ($\ddot{l} \gtrless g$), the motion of the pendulum will always be oscillatory about the vertical with growing angular amplitudes of acceleration of the load. Thus, author considers that for a hoisting arrangement, one critical condition arises when one load is being raised. Apart from the integrated case of $\ddot{l} = g$, no other rigorous solutions of Eq. [1] are presented. There are some misprints.

M. P. Gulyaev
Courtesy Referativnyi Zhurnal, USSR

4516. Davenport, A. G., The wind-induced vibration of guyed and self-supporting cylindrical columns, *Trans. Engng. Inst. Canada* **3,** 4, 119–141, Dec. 1959.

Part I examines existing knowledge of wind-induced vibration of cylindrical bodies. Part II analyzes the dynamic effect of a guy cable, and obtains equations leading to the natural frequencies and modes of a guyed cylindrical structure in terms of "basic functions," i.e. normal modes of a uniform beam.

J. D. Robson, Scotland

4517. Pei, M. L., Natural frequency of beams with variable moments of inertia, *J. Aero/Space Sci.* **27,** 4, 304–305 (Readers' Forum), Apr. 1960.

4518. Lewis, F. M., A modification of Rayleigh's principle for calculating beam frequencies, *ASME Trans.* **81**E (*J. Appl. Mech.*), 3, 452–454 (Brief notes), Sept. 1959.

Method described, which is limited to hinged-end, cantilever, and free-free beams, involves assuming slightly different deflection curves in computation of potential and kinetic energies. Although results can be made reasonably accurate, author points out that the condition that Rayleigh's theorem always gives too high a frequency is no longer applicable for this modification.

N. M. Newmark, USA

4519. Romiti, A., Critical speed of rotating beams with distributed elastic mass (in Italian), *Atti Accad. Naz. Lincei, R. C. Cl. Sci. Fis. Mat. Nat.* (8) **25,** 3/4, 174–183, Sept./Oct. 1958. (Obtainable from Centro Studi Dinamica dei Fluidi, Politecnico de Torino Istituto di Aerodinamica e Meccanica Applicata, Mono. 426.)

Author studies critical speeds of shafts with distributed mass, asymmetrical elasticity, eccentricity, in the general case when these quantities vary along the shaft and gravity is also taken into account. The first step consists in writing the differential equations of equilibrium in two orthogonal planes, for an ideal shaft (no mass eccentricity, no gravity, no elastic asymmetry), taking into account gyroscopic moments. Their solution shows that for every angular speed ω of the shaft, two rigid rotations of elastic line with angular speed p generally different from ω are possible. When $p = \pm\omega$, the well-known speeds "im Gleichlauf" and "im Gegenlauf" are found again. In the second step, the shaft is supposed to have, in every section, two different principal (orthogonal) elastic rigidities, and mass (distance and phase) eccentricity, all these quantities varying along its axis. The corresponding equations are written and solved in the following cases:

(1) Gyroscopic moments, gravity and mass eccentricity are omitted; only elastic asymmetry is taken into account and supposed to be the same in every section. It is found that for every critical speed of the shaft with elastic symmetrical section an interval of instability takes place, of amplitude increasing with percentage of elastic asymmetry.

(2) Constant elastic asymmetry and gravity without eccentricity are taken into account. Particular integrals are found showing that gravitational resonance takes place for a speed near half of the critical speed of a shaft with constant rigidity.

(3) Constant elastic asymmetry, and constant (distance and phase) mass eccentricity are taken into account. It is found that resonance takes place when the number of revolutions of the shaft equals the frequencies of a shaft having constant rigidity equal to the maximum or minimum rigidity of the real shaft. Final considerations about the several types of critical speeds are developed.

Moreover it is shown that a possible damping would reduce the amplitudes in resonance, but would not eliminate the instabilities due to elastic asymmetry.

Reviewer believes this paper to represent real progress in the theory of critical speeds for shafts with distributed mass, owing to the strong derivation of its equations and to their elegant and strong solutions. R. Giovannozzi, Italy

4520. Mulin, S. M., The dynamic rigidity of the two-dimensional bending of a strip beam (in Russian), *Sb. Naucbn. Trudi Tomskii Elektromekh. In-ta Inzh. Zh.-d. Transp.* **23,** 80–100, 1957; *Ref. Zh. Mekh.* no. 8, 1958, Rev. 9108.

An approximate solution is presented of the problem of the rigidity in the two-dimensional form of bending of a strip loaded in the plane of maximum rigidity by periodic forces. The differential equations of the problem are replaced by equations of the differences (of the spatial variable), which are written in matrix form. The method used for constructing the regions of instability

is that suggested by the reviewer [*Inzhener. Sbornik* **14**, 10–122, 1953]. Since the paper does not take account of the inertia terms corresponding to the torsional vibrations, the results obtained are useful only for finding the region of predominantly flexural vibration and only if the partial frequencies of the bending and torsional vibrations differ sufficiently from each other.

V. V. Bolotin

Courtesy Referativnyi Zhurnal, USSR

4521. Molder, I. K., The free transverse vibrations of a buckling bar (in Russian), *Zinatn. Raksti.-Latv. Univ.* **10**, 71–80, 1957; *Ref. Zh. Mekh.* no. 8, 1958, Rev. 9093.

The vibrations of a slightly bent rod with fixed hinged supports at the ends, compressed by an initial force S_0, are analyzed from the aspect of the reactive, axial force. The approximate equation of the problem

$$EI\frac{\partial^4 y}{\partial x^4} + \left[S_0 - \frac{EF}{2l}\int_0^l \left(\frac{\partial y}{\partial x}\right)^2 dx\right]\frac{\partial^2 y}{\partial x^2} + m\frac{\partial^2 y}{\partial t^2} = 0$$

(in the current notation) is reduced by the substitution of

$$y(x, t) = H(t)\sin\frac{\pi x}{l}$$

to the form

$$m\ddot{H} + \alpha H^3 + \delta H = 0$$

which is capable of integration in integral functions. There is a considerable difference between the theoretical and the experimental results.

V. V. Bolotin

Courtesy Referativnyi Zhurnal, USSR

4522. Iida, S., The critical speed of a shaft rotating in fluid, *Bull. JSME* **2**, 8, 532–537, Nov. 1959.

Author examines the effects of a surrounding fluid on the first critical speed of a shaft which rotates in a cylindrical casing. Although results are of great interest, they pose several problems which are not examined. For instance, what is a "critical speed"; author's definition is a little unorthodox.

R. E. D. Bishop, England

4523. Gladwell, G. M. L., and Bishop, R. E. D., The receptances of uniform and non-uniform rotating shafts, *J. Mech. Engng. Sci.* **1**, 1, 78–91, June 1959.

Expressions are found for the receptances of flexible rotating shafts.... They permit the investigation of the motion at critical speeds and the stability of shafts in flexible bearings.

From authors' summary by H. Deresiewicz, USA

4524. Federhofer, K., Nonlinear bending vibrations of a circular ring (in German), *Ing.-Arch.* **28**, 53–58, Mar. 1959.

Title implies nonlinear strain-displacement relations, but retention of linear stress-strain law. Resulting system of equations is similar to conventional linear system, but with corrective second-order terms added. Single iteration is used to obtain approximate solution; as expected, influence of nonlinear terms is small for most practical purposes.

Reviewer believes that introduction of nonlinearity is not uniformly consistent, as e.g. in choice of direction of inertia forces. Verification of numerical results therefore appears to call for more rigorous analysis or experimental corroboration.

E. F. Masur, USA

4525. Sushtchikh, M. V., The free oscillations of a pressure-reducing valve (in Russian), *Trudî Leningrad Voyen.-Mekhan. In-ta* no. 6, 249–260, 1957; *Ref. Zh. Mekh.* no. 8, 1958, Rev. 8407.

An investigation of the free vibrations of a gas pressure-reducing valve (a direct-acting pressure regulator) for reducing and maintaining the pressure in gas service mains. The nonlinearly diverging characteristics are interpolated by polynomials. After which the natural vibrations are found by the method of balancing the harmonics.

M. A. Aizerman

Courtesy Referativnyi Zhurnal, USSR

4526. Pluzhorikov, G. T., The free oscillations of ribbed plates (in Russian), *Nauchn. Zap. Kievsk. Finans.-Ekon. In-ta* no. 3, 190–193, 1953; *Ref. Zh. Mekh.* no. 8, 1958, Rev. 9086.

A method is proposed for determining the natural frequencies of reinforced-concrete, ribbed slabs, with the ribs running parallel to one of the sides; the ribs are of equal rigidity, and equally spaced. It is assumed that the ribs and the slabs form a monolithic structure. By dividing the slab into separate tee sections and determining the rigidity of each such section, author obtains a supplementary rigidity factor, which is added to the rigidity of the individual rib. In the further development, the problem is solved by a method developed by A. S. Lokshin [*Prikl. Mat. Mekh.* **2**, no. 2, 1935]. Experimental and analytical data are presented; the divergence is approximately 10%.

A. V. Karmishin

Courtesy Referativnyi Zhurnal, USSR

4527. Shatashvili, S. Kh., A combined problem of the theory of steady-state, elastic oscillation (in Georgian), *Trudî Gruz. Politekhn. In-ta* no. 4, 81–90, 1957; *Ref. Zh. Mekh.* no. 8, 1958, Rev. 9078.

Author investigates the two-dimensional, combined problem of steady-state, elastic oscillation, using potentials equally suitable for finite (simply linked) and infinite regions. The tangent component of the stress vector and normal component of the displacement vector at the boundary are given. The final results are presented as capable of solution by Fredholm integral equations.

K. I. Ogurtsov

Courtesy Referativnyi Zhurnal, USSR

4528. Sykes, A. O., The effects of machine and foundation resilience and of wave propagation on the isolation provided by vibration mounts, David W. Taylor Mod. Basin Rep. 1276, 19 pp., Jan. 1959.

Author employs impedance concept to develop vibration isolation relations between nonrigid machine and foundation, separated by resilient mount that may also sustain wave motion. Evaluation is in terms of "effectiveness," ratio of velocities at machine-foundation junction before and after adding mount. Effectiveness is same as insertion loss in electrical network theory on which development is based. If mount is more than 1/6 wavelength long, wave effects become important. Effects due to resonances in mount are reduced if velocity in mount decreases as frequency increases. Reviewer considers paper to be a thorough summary of and definitive monograph on topic.

V. Salmon, USA

4529. Naumkina, N. I., Tartakovskii, B. D., and Efrussi, M. M., Experimental study of some vibration-absorbing materials, *Soviet Phys.—Acoustics* **5**, 2, 196–201, Nov. 1959. (Translation of *Akust. Zh., USSR* **5**, 2, 196–201, Apr./June 1959 by Amer. Inst. Phys., New York, N. Y.)

An experimental procedure is described for investigating the dynamic elastic properties of materials used for the attenuation of vibrations which are being propagated through the metal elements of machinery and constructions.

The dynamic Young's moduli and the loss coefficients of a group of synthetic materials made from a base of bitumen, reprocessed salvage rubber, and various fillers are measured. The Young's modulus for these materials ranges from $2 \cdot 10^9$ to $6 \cdot 10^{10}$ dynes/

cm^2 and the corresponding loss coefficients are 0.4 – 0.1. The measurements were made in the interval 10–100 cps.

One of the best vibration-absorbing materials is bitumen-impregnated felt (Young's modulus, 10^9 dynes/cm^2; loss coefficient, 2.5). From authors' summary

4530. Yakovlev, A. P., The effect of the shape of transverse vibration upon the damping ratio, *Indust. Lab.* **25,** 2, 217–220, Mar. 1960. (Translation of *Zavod. Lab., USSR* **25,** 2, 206–208, Feb. 1959 by Instrument Society of America, Pittsburgh 22, Pa.)

4531. Akatnov, N. I., and Sabaitis, Yu. I., Measurement of rotational derivatives by the method of auto-vibrations (in Russian), *Zh. Tekhn. Fiz.* **26,** 9, 2049–2056, 1956; *Ref. Zh. Mekh.* no. 2, 1959, Rev. 1276.

4532. Taniguchi, O., Sakata, M., and Suzuki, M., On the steady state motion of electro-magnetic vibrator, *Bull. JSME* **3,** 9, 87–95, Feb. 1960.

In vibratory machines electro-magnetic vibrators are frequently used as the source of vibration. These vibrators are of moving-coil or electro-magnet type and are excited with sinusoidal or half-wave rectified current.

In order to investigate the fundamental performance of vibratory machines, the steady-state motion of vibrators and that of an ideal vibratory machine with two-degrees-of-freedom system are analyzed by an approximate method. The performance obtained from this analysis is found to agree well with the experimental results. From authors' summary

Wave Motion and Impact in Solids

(See also Revs. 4420, 4462, 4513, 4520, 4528, 4614, 4915, 4916, 4932)

4533. Karal, F. C., Jr., and Keller, J. B., Elastic wave propagation in homogeneous and inhomogeneous media, *J. Acoust. Soc. Amer.* **31,** 6, 694–705, June 1959.

The linearized equations of the propagation of small amplitude elastic waves in homogeneous or inhomogeneous media are usually solved assuming the separability of the variable. Authors have introduced a new method of solving the problem, based upon an expansion in inverse powers of the frequency. This method was devised by Luneberg.

As a solution to the wave equation one particle displacement is taken in the form, $u = Ae^{i\omega(S-t)}$, where A and S are functions of x, ω being the constant angular frequency of the solution. S is assumed independent of ω and A has an expansion of the form $A = \sum_0^\infty (i\omega)^{-n} A_n$. Two cases are then considered for the determination of A, using forms of the well-known eiconal equation of geometrical optics, i.e.

$$\text{I} \begin{cases} A_0 \nabla S = 0 \\ (\nabla S)^2 = \rho \mu^{-1} \end{cases}$$

$$\text{II} \begin{cases} A_0 x \nabla S = 0 \\ (\nabla S)^2 = \rho (\lambda + 2\mu)^{-1} \end{cases}$$

The A_n are first determined in case I by successively setting $n = 1.2$ in the basic differential equation.

Proceeding in a similar manner for any value of $n \geq 0$, the inhomogeneous equation for A_n is obtained:

$$2(\nabla S \cdot \nabla) A_n + (\nabla^2 S) A_n = F_n - 1$$

where $F_n - 1$ depends only upon $A_n - 1$, $A_n - 2$ and is given by Eq. [22] of the paper.

The expression of u is finally obtained upon the assumption that the energy, which is proportional to $(A)^2$ travels according to the law of geometrical optics, the $A_0(S)$, where S is an arc length along the ray, varying inversely as the square root of the cross-sectional area of a narrow tube of rays.

In the solution of u in case II the same method is being used which yields Eq. [44].

In general u is the sum of both solutions with appropriate boundary conditions.

A more general waveform is also introduced, following Friedlander, where

$$u = \sum_{n=0}^{n=\infty} A_n E_n (S - t)$$

where $E_n(S-t) = (i\omega)^{-n} e^{i\omega(S-t)}$.

Upon insertion into [1], E_n may be obtained by requiring the coefficient of each E_n to vanish.

From an inhomogeneous medium the rays being no longer straight lines, a system of two differential equations is obtained for the $X(S)$ which represent the equation for shear waves and compression waves. Once the rays are known the amplitudes A_n are obtained for both cases and it is shown that the magnitude of A_0 varies in accordance with the principle of conservation of energy within a narrow tube of rays. In the case of shear, A_0 lies in the plane normal to the ray and rotates around the ray as it progresses, while in the case of compression it always remains parallel to it.

In the summary, authors explain how to use the method to solve a particular problem where the wave motion is produced by a point source Q. G. E. Jarlan, Canada

4534. Khalevin, N. I., A question regarding the measurement of the velocities of elastic waves in conditions of natural stratification of the rock (in Russian), *Trudi Gorno-geol. In-ta Ural'skii Fil. Akad. Nauk SSSR* no. 30, 133–141, 1957; *Ref. Zh. Mekh.* no. 2, 1959, Rev. 1851.

Apparatus is described which was designed in the mining-geological institute of the Ural'sk affiliation of the Akademeyi Nauk, SSSR for the measurement under field conditions of the velocities of propagation of elastic waves over the surface of rock strata. Results are given for the observations made on the sedimentary mesokaphnozoic deposits with a profile length of up to 10 m and on rocks of lithoidal origin with a profile length of up to 25 m. Velocities are determined of the propagation of the longitudinal and of the transverse waves. K. I. Ogurtsov

Courtesy Referativnyi Zhurnal, USSR

4535. Makinson, K. Rachel, Some speculations on possible instability phenomena in the mechanical behaviour of proteins, Proc. Int. Wool. Text. Res. Conf., Australia, 1955, D-55-D-61.

There appears to be no sound basis in elasticity theory for the common assumption that the strain-energy function must necessarily be unique, i.e. that the elastic-constant matrix must necessarily be symmetrical, under all conditions. If this requirement does not hold for a particular solid, observable effects will be produced: the directions of vibration of the three elastic waves which can be propagated freely in any direction in the solid will not be mutually perpendicular. In a special case, which is discussed, circularly polarized waves will be propagated freely, with amplitudes which are exponential functions of the distance of propagation.

Two types of structure which could give rise to such phenomena are described in broad outline: the discussion of these structures indicates that such phenomena probably can occur only in solids, such as long-chain polymers and proteins, which contain very large and complex lattice units. One of the structures described is based specifically on the α-keratin helix.

From author's summary

4536. Jones, R. P. N., The generation of torsional stress waves in a circular cylinder, *Quart. J. Mech. Appl. Math.* **12,** 3, 325–336, Aug. 1959.

The Pochhammer-Chree theory of harmonic wave propagations in a bar of circular section shows that types of torsional wave motion are possible in which the displacements over the cross section have one or more nodal circles. The theory of the present paper may be regarded as an extension of the Pochhammer theory. It is a solution in series form. The first term gives the elementary theory. The initial value problem for a bar of infinite length, for semi-infinite bar and for a bar of finite length are discussed on the basis of the general theory. The problem, in which stress waves are generated by the sudden application of an external torque at the surface of the bar gives displacements fairly accurately by elementary theory, except in the neighborhood of the wave front. Here the general theory is necessary.

The importance of the higher modes of wave propagation depends greatly on the manner in which the waves are generated. Only in the particular case where the initial conditions or the applied stresses themselves conform to the elementary theory will the higher modes be absent. When torsional waves are generated by shear stresses at the end of a bar, the higher modes are important at the wave front as well as at the end where the stresses are applied. The elementary theory is unsatisfactory in these regions.

The measurements of Davies and Owen are in agreement with the conclusions of paper. L. Foppl, Germany

4537. Knopoff, L., Scattering of compression waves by spherical obstacles, *Geophysics* **24,** 1, 30–39, Feb. 1959.

The scattering of plane P waves by a spherical obstacle is formulated. A calculation is given for the special case of scattering by a perfectly rigid sphere in which the medium outside has a Poisson's ratio of 1/4. The range of sizes of obstacles used in the calculation includes radii very small compared with wavelength and radii comparable to the wavelength. For incident P waves, scattered P and S are computed with shifts in time phase occurring in both with respect to the incident beam. For small obstacles, the scattered S wave is generally broadside to the scattered P-wave beam.

From author's summary by K. Kasahara, Japan

4538. Kaliski, S., and Osiecki, J., The problem of reflection by a rigid or elastic wall of an unloading wave in a body with rigid unloading characteristics (in English), Proceedings of Vibration Problems (*Polska Akad. Nauk, Inst. Podstawowych, Probl. Techn.*) no. 1, 83–99, 1959.

This paper is based on a previous one by the same authors which dealt with one-dimensional unloading waves in a beam or plate with rigid unloading characteristics, i.e., unloading under constant strain [title source no. 1, p. 1, Warsaw 1959]. Present paper discusses the reflection of such waves at a rigid or elastic end. It draws from conclusions and uses nomenclature of aforementioned previous paper, and should be read in conjunction with it. Main consequence of rigid unloading characteristics is that, whereas in regions of increasing load disturbances propagate in the form of waves, in unloading regions the medium behaves as a perfectly rigid body. Authors state that in spite of this qualitative difference with reality their results approximate very well quantitatively the behavior of materials with high unloading modulus such as soils. In the analytical treatment of the paper the further simplifying assumption of linearly elastic loading characteristics is made. Under these assumptions the authors obtain a closed form solution of their problem by considering successively the different solution regions in the x,t plane. Solutions in these regions are obtained by direct integration of equations of motion of rigid portions of the beam, and by application of formulas for the unloading wave obtained in above-mentioned previous paper. Solution is given for an arbitrary unloading function, and then applied to the specific example of reflection by a rigid end of a load decreasing linearly from an initial value at $t = 0$ to zero and $t = \tau$, and remaining zero for $t > \tau$.

Reviewer concurs with authors' suggestion that their solutions give insight to problems in soil mechanics such as loading-unloading of a soil layer resting on deformable or rigid structures.

D. C. Gazis, USA

4539. Mamontov, M. A., Calculations for blows loosening wedges (in Russian), *Trudi Tul'sk. Mekh. In-ta* no. 8, 85–95, 1958; *Ref. Zh. Mekh.* no. 2, 1959, Rev. 1202.

The impact which loosens a wedge is investigated with consideration for the impact impulses of friction, and formulas are derived which deal with the different variants met with in this type of impact. S. G. Kislitsyn

Courtesy Referativnyi Zhurnal, USSR

4540. Evans, J. F., Seismic model experiments with shear waves, *Geophysics* **24,** 1, 40–48, Feb. 1959.

Application of shearing source to supersonic model experiments has been developed. By use of this type of source, author demonstrates production of SH-waves, simplicity of SH-wave reflections in single homogeneous layer, and development of relatively high amplitude Love waves in low-velocity surface layer. Results of these experiments are in general agreement with and confirm theory. They also agree with results of field experiments in scattered cases for which comparison is available. Author expects that this new technique will be usefully applied to studies of wave phenomena in which shear components play important role.

K. Kasahara, Japan

4541. Bartlett, R. W., Observations of vaporization accompanying ultra-high velocity impact, AFOSR TN 60–327 (Inst. Metals Explosives Res., Univ. Utah), 24 pp., Jan. 1960.

This study of the behavior of metals under ultra-high velocity impact emphasizes the vaporization and penetration of metals. Jets from shaped charges and discrete particles accelerated by high explosives were used as projectiles. Studies were made at velocities up to 8.5 km/sec using a variety of target and projectile metals.

The explosive techniques employed were capable of generating velocities sufficiently high to produce target vaporization in many metals. These impact-generated vapors were sufficiently luminous for short periods of time to be photographed, and they exhibited considerable electrical conductance, evidencing a high degree of ionization which decayed faster in air and various inert gases than in vacuum. Because of the high luminosity and the ionization of the impact-generated metal vapors or plasmas high-speed framing camera techniques and electrical conductivity measurements were employed. Small quantities of the condensed vapors also were collected and analyzed quantitatively to determine the ratios of the projectile or jet to target metals in the vapor condensate as a function of impact velocity. In most cases mixtures of metal oxides were indicated but the x-ray diffraction patterns did not permit conclusive indentification of specific compounds. Some condensation of reduced metal also was observed (aluminum, iron and zinc) and a substitutional solid solution alloy, alpha brass, was produced by the simultaneous condensation of copper and zinc vapors originating from different targets impacted in tandem.

From author's summary

Soil Mechanics: Fundamental

(See also Revs. 4538, 4926)

4542. Hough, B. K., Compressibility as the basis for soil bearing value, *Proc. Amer. Soc. Civ. Engrs.* **85,** SM 4 (*J. Soil Mech. Foundations Div.*), 11–39, Aug. 1959.

It is well known that if foundation design on compressible soils is based merely on the concept of providing a constant factor of safety against soil rupture, adjacent footings are likely to settle differently under the design load. Author considers carefully this fact and points out the opportunity of determining allowable bearing values chiefly with reference to soil compressibility.

Assuming homogeneous soil and one-dimensional compression with reference to individual footings author develops an expression for the particular value of contact pressure which will not cause more than a specified amount of settlement. The value obtained is a function of footing width, foundation depth, tolerable settlement, unit weight and compressibility of soil. As a result of this analysis, a procedure for designing footings based on the concept of equalizing settlements due to soil compression is proposed.

The contribution can be of great help to the practicing engineer, especially because the interrelationships of the many variables which affect the settlement of footings on compressible soils are clearly presented. R. Jappelli, Italy

4543. Matlock, H., and Ripperger, E. A., Measurement of soil pressure on a laterally loaded pile, *Proc. Amer. Soc. Test. Mat.* **58,** 1245–1260, 1958.

The procedures required to obtain accurate test results in the measurement of moments in a steel shell pile under lateral load using the strain-gage method are presented in excellent detail. Types of gages, lead connections, method of attaching and sealing against moisture, bridge circuit, method of calibration before driving pile, are discussed. Degree of accuracy of all steps is indicated. Conclusion: Moment data of sufficient precision for calculating reliable soil reaction distributions on a laterally loaded pile can be obtained using the strain-gage method.

F. J. Converse, USA

4544. Barshevskii, B. N., Some questions regarding the distribution of stresses in a soil with deformability characteristics varying with depth (in Russian), Report of the 16th Scientific Conference of the Proff-Lecturer Staff of the Leningrad Inzh.-Stroit. In-ta, Leningrad, 1958, 142–146; *Ref. Zh. Mekh.* no. 2, 1959, Rev. 1806.

The author demonstrates, by means of a number of examples of the plane problem, that a very real influence on the stressed state of the soil is found to be the growth with depth of its modulus of deformation caused by the all round compression of the soil's upper layers. The author records the initial differential equation applicable to variable deformability characteristics, while taking into account the equations of equilibrium and the conditions of cooperative action; these are expressed in cylindrical coordinates in the form

$$\Lambda^2\left[\frac{(\sigma_r+\sigma_\beta)}{2}\left(\frac{1}{K_1}+\frac{1}{G}\right)\right]=\sigma_r\frac{\partial}{\partial}\left(\frac{1}{G}\right)+$$

$$+\sigma_\beta\left[\frac{\partial}{r\,\partial r}\left(\frac{1}{G}\right)+\frac{\partial^2}{r^2\partial\theta^2}\left(\frac{1}{G}\right)\right]+2\,\tau_r\left[\frac{\partial}{r\partial\theta}\left(\frac{1}{G}\right)\right]$$

Here Λ^2 is Laplace's operator, K_1 is the modulus of volumetric-plane compression, G is the modulus of shear. In the above calculations both the moduli, in correspondence with the results of the experiments made, are taken to be proportional not to the first degree but to the square root of the depth h. The solution of concrete problems depends upon finding the stress function satisfying this equation and the assigned boundary conditions. In particular, author uses this method for solving the problem of the distribution of stresses produced by a concentrated force applied to the surface of the soil. In the case of a horizontal force with an indicator of the heterogeneity of the soil $n = 0.5$ this solution, obtainable by the use of the formula $\sigma_r = \frac{P_x}{0.972}\sin\theta\sqrt{\cos\theta}$ differs qualitatively from the corresponding solution in the theory of elasticity.

A. I. Govyadinov

Courtesy Referativnyi Zhurnal, USSR

4545. Pil'gunova, Z. V., The method of mathematical statistics in the establishment of a mean value for the resistance to shear of clay beds (in Russian), *Trudi Labor. Gidrogeol. Problem. Akad. Nauk SSSR* **14,** 233–242, 1957; *Ref. Zh. Mekh.* no. 2, 1959, Rev. 1830.

A description is given of a method of calculation based on a given number of experimental determinations of the resistance to shear of a soil, taken from a geological section of a layer of soil, with such a value for this indicator of the properties of the soil which, for a given number of determinations, would possess the given probability. It was established that use of the method advocated for the calculation would be permissible in practice in engineering-geological works, were analysis of the natural-historical conditions for the layer of soil able to prove that this method for it is permissible and justifiable, and if the numerical values of the experimental indicators have a normal distribution, while the number of tests of soil samples, selected in a proper sequence, corresponds to the requirements of the case.

S. A. Roza

Courtesy Referativnyi Zhurnal, USSR

4546. Rozovskii, M. I., Study of the state of stress around horizontal cavities, taking after-effect in various rock types into account (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 12, 66–72, Dec. 1958.

Author uses integral operators of the memory-function type to represent the generalized elastic constants of the material. Two-dimensional systems (tunnels of infinite length) are considered, the boundary conditions being expressed by expansion into trigonometrical functions. After deriving a general, symbolic solution, author specializes to memory functions of the form of decreasing exponentials, and gives numerical results of four special cases, for parameter values attributed to sandstone, limestone, rock salt, and heavy clay. F. C. Roesler, England

4547. Muzgin, S. S., The breaking down of frozen soils (in Russian), *Trudi In-ta Gorn. dela, Akad. Nauk KazSSR* **2,** 124–136, 1957; *Ref. Zh. Mekh.* no. 2, 1959, Rev. 1831.

The breaking down of frozen soils is investigated when this is being done by means of wedge-shaped cutting gear with impact action. Results are given for the experimental investigation of the character of the breaking-down of various frozen soils from which it is seen that the breaking-down is accompanied by the formation of a compacted core at the edges of the wedge; this accounts for ~80–90% of the work expended on the breaking-down. It is further established that the breaking-down of frozen clay soils demands the expenditure of a larger quantity of energy than that required for sand soils. Formulas are given for the calculation of the work involved in separate parts of the process of the breaking-down of frozen soils. V. G. Berezantsev

Courtesy Referativnyi Zhurnal, USSR

4548. Zelenin, A. N., Veselov, G. M., and Stepanov, A. P., The general nature of the principles governing changes in the resistance of frozen soils when being broken down (in Russian), *Str-vo Predpriyatii Neft Prom-sti* no. 12, 7–11, 1957; *Ref. Zh. Mekh.* no. 2, 1959, Rev. 1832.

The results are published in eight graphs and two tables of the experimental determination of the resistance characteristics of a

frozen soil, when subjected to single axis disruption, single axis compression, wedge impact loading, cutting, static embedding of a die and dynamic embedding of a die. A heavy sandy loam soil with a plasticity number of 7.9 and humidity between 19 to 23 (which corresponded to the maximum resistance of this soil) was subjected to these investigations in a temperature range of -1 to -40°. Tests for destruction were carried out with samples of the undamaged soil structure, the samples being of "figure-of-eight" shape, but also with hollow cylindrical samples. Compression under a press was carried out on cubes $15 \times 15 \times 15$ cm cut out from the soil mass. The cutting of the soil was done with a cutter 3 cm in width. The static and dynamic embedding of a cylindrical die 1 cm^2 in section was carried out to a depth of 10 cm. Wedge penetration of the soil was done with a wedge 40 mm in width with an angle of 30°, set at 40 mm from the edge with a load of 2.5 kg falling from a height of 40 cm. The authors came to the conclusion that there is not only a qualitative but also a quantitative generality of the principles governing the changes of the resistance properties of a frozen soil with different forms of destruction in relation to the temperature and proposed the following general equation to describe these principles $x = A\sqrt{t}$, where x is the destructive stress (kg/cm) with different ways of causing the destruction, t is the magnitude of the negative temperature in degrees, A is the resistance coefficient, characterising the specific resistance capacity of the soil when disrupted by one or other means. For the sandy loam soil being investigated the following values for the coefficient A were obtained: tension–10, compression–30, cutting–115 and static embedding of a die–210. The investigations carried out enable a choice to be made of the most efficient ways for breaking down of frozen soil in the production of earth works and also to evaluate the stressed state of the soil mass under the action of various loads resulting from constructions on it.

G. K. Klein

Courtesy Referativnyi Zhurnal, USSR

4549. Kogan, Ya. L., Gas content determination in a saturated sand by freezing (in Russian), *Gidrotekh. Stroit.* **28**, 2, 46–48, Feb. 1959.

Under water table to depth of 3 to 3.5 m soil (sand) still contains from 4 to 6% of air. This air content decreases soil permeability and settlement time as well as the velocity of propagation of short pulses waves. Air content may be determined on undisturbed samples bored after freezing. Author's formula, verified by research in laboratory, is

$$v = \left(\frac{\gamma_n - \gamma_c}{\gamma_n} - \frac{\gamma_m - \gamma_e}{\gamma_i} \right) 100\%$$

where v denotes air content per volume unit, γ_m average unit weight of frozen soil, γ_e average unit weight of solid constituents, γ_n specific gravity of soil particles, and γ_i specific gravity of ice.

K. Gamski, Belgium

Processing of Metals and Other Materials

(See Revs. 4443, 4815)

Soil Mechanics: Applied

(See also Revs. 4542, 4543, 4549, 4636, 4927)

4550. MacGregor, C. W., and Palme, R. B., The distribution of contact pressures in the rolling of metals, *ASME Trans.* **81** D (*J. Basic Engng.*), 4, 669–680, Dec. 1959.

This paper presents results of experimental measurements of pressure distributions along the arc of contact in the rolling of metals. Measurements have been made for square bars and flat strips. The work reported is part of that reported in an ASME Research Report on plastic flow of metals published in 1958, "Rolling of metals" by the same authors.

The paper brings to light new facts about the pressure distribution in flat rolling. The measurements on square bars show double peaks in the pressure distribution, one near entry and the other near the roll centerline. Measurements on flat strip show a pressure peak near the centerline only.

It is interesting to note that J. M. Alexander in his paper "Slip line field for the hot rolling process" [*Proc. Instn. Mech. Engrs.* **169**, 1021–1028, 1955] found it necessary in his analysis to postulate a surface region of "rigid" material close to the entry into the roll gap. This may offer an explanation for the phenomenon observed.

An analysis is conducted to predict approximately the pressure distribution curves from stress-strain data. The predicted distributions of contact pressures are in fair agreement with the measured values.

A. H. El-Waziri, USA

4551. Stone, M. D., The effects of friction in the rolling of metals, *ASME Trans.* **81** D (*J. Basic Engng.*), 4, 681–686, Dec. 1959.

Present paper is a review of published work concerned with friction in rolling rather than an original contribution and, as would be expected, treats cold and hot rolling separately. Major part of treatment of cold rolling is review and discussion of effect of rolling speed on friction. Discussion of hot rolling is a little more detailed and, after considering friction in relation to forward slip, author summarizes his own work (based on von Karman and Nadai) concerning effect of friction on rolling pressure and minimum gage.

R. C. Brewer, England

4552. Woo, D. M., and Marshall, J., Spring-back and stretch-forming of sheet metal, *Engineer* **208**, 5405, 135–136, Aug. 1959.

Authors have studied the forming of sheet metal strips into plain curved parts. The spring-back when load is removed is then essential for the shape accuracy. First the spring-back in pure bending is calculated. An expression is derived for the curvature before and after load removal for a material with nonlinear strain-hardening. Calculations show a severe spring-back when the ratio of forming radius to metal thickness is large. Spring-back is reduced if a tensile force is applied during the forming. Here a linear strain-hardening material is assumed in deriving the change of curvature at load removal. Analysis has been verified by experiments.

A. Isaksson, Sweden

Book—4553. Agte, C., Kohlermann, R., and Heymel, E., Ceramics for cutting tools—Manufacture, properties and application [Schneidkeramik–Herstellung Eigenschaften und Anwendung], Berlin, Akademie-Verlag, 1959, xi + 203 pp. DM 19.50.

Book is one of the few publications covering with sufficient comprehensiveness the technology of ceramics and allied materials (cermets and oxide-carbide mixtures) as used for machining of metals and other materials. A brief history of tool materials is followed by a review of progress of ceramics in main industrial countries, particularly in Eastern Germany where it seems research is fostered by the scarcity of some materials used for more conventional tools.

Remaining chapters cover properties of ceramics, cermets and oxide-carbide mixtures; comparison of these with carbides; manufacturing techniques and plant; geometry of tools; methods of holding tips; feeds and speeds; requirements as regards fixtures and machine tools; field of application for ceramics, carbides and HSS cutters; and economics of application. Last chapter outlines scope of future development in this field. In their concluding

chapter authors admit book will quickly become obsolete because of rapid development, and state they are already considering a revised edition within the next few years. Reviewer considers this a comprehensive and useful presentation of the art at the time of preparation of manuscript (1958), and can thoroughly recommend this book to engineers and students interested in technology of cutting. There are 233 references, mainly German. Line diagrams, charts and photographs are excellent.

J. J. Dee, England

4554. Gideon, D., Simon, R., and Grover, H., The mechanism of chip formation, Amer. Soc. Tool Engrs., Collected Papers 1958, Book 1, Pap. 75, 8 pp., 1958.

Paper reviews the literature on chip formation during orthogonal machining. Emphasis is on methods of predicting the angle φ of the shear plane. The assumptions made by various authors in attempting to predict φ are discussed and criticized qualitatively. Reviewer believes that article forms a good general introduction to the problem of predicting the shear angle in metal cutting.

I. Finnie, USA

4555. Rozenberg, L. D., and Kazantsev, V. F., The physics of ultrasonic processing of solids, *Soviet Phys.-Doklady* **4,** 1, 182–185, Aug. 1959. (Translation of *Dokladl Akad. Nauk SSSR (N.S.)* **124,** 1, 79–82, Jan./Feb. 1959 by Amer. Inst. Phys., Inc., New York, N. Y.)

In performing experiments in regard to the nature of the forces producing the impact of the abrasive particles in the ultrasonic machining of glass and similar brittle solids, a 50% suspension of B_4C (ca 220 μ) in water or glycerine is brought between a cover glass of ca 0.1-mm thickness and a razor blade which is fastened to the end of a magnetostriction vibrator (6.8 kc). The motion of the particles can be observed through a glass plate and is recorded by a high-speed cine-camera with a resolving power of 40 lines/cm on 8-mm film in transmitted light at speeds of 20,000 and 50,000 frames/sec. Not all types of particle motion were effective in removing particles from the glass surface, even when particle velocity is almost the same as the maximum vibrator velocity (up to 300 cm/sec). The glass surface was only affected by the direct impact of the transducer against abrasive B_4C-particles located immediately on the glass surface.

O. E. Ruediger, Germany

4556. Pines, B. Ia., and Sirenko, A. F., Self-diffusion and heterodiffusion in nonhomogeneous porous bodies, Part 2, The direct and reverse Frenkel effect; Part 3, Occurrence of the Frenkel and Kirkendall effects in the sintering of specimens of powder mixtures of mutually diffusing metals, *Soviet Phys.-Tech. Phys.* **3,** 8, 1612–1616, Mar. 1959; **4,** 5, 582–589, Nov. 1959. (Translation of *Zh. Tekh. Fiz., USSR* **28,** 8, 1748–1752, Aug. 1958; **29,** 5, 653–662, May 1959 by Amer. Inst. Phys., Inc., New York, N. Y.)

Heterodiffusion is accompanied, in addition to mixing of constituent atoms, by a porosity effect. This effect appears to leave a "fine porosity" in the component from which the atoms escape during diffusion. Authors claim this is due to the vacancy mechnism of diffusion and so prefer to identify it with the Frenkel effect rather than assign it the name "Kirkendall effect," which has appeared in the literature. The phenomenon of the flow of vacancies is, in a way, the negative to the flow of atoms in the diffusion process, thus a "reverse" Frenkel effect. Nonhomogeneity in concentration thereby results in an alloy originally homogeneous.

Three alloys were experimentally investigated. By sintering Cu-Ni, Fe-Ni and alpha-brass the reverse effect was confirmed.

An experimental as well as mathematical investigation of the "growth" phenomenon in the sintering of mutually diffusing metal powders is reported in the last paper. It is concluded the growth in volume is due to an increase in porosity caused primarily by the Frenkel effect. It is also concluded that a gradual equalization of diffusion coefficients exists. Therefore, cessation of "growth" occurs before homogeneity in concentration is reached.

J. P. Vidosic, USA

Fracture (Including Fatigue)

(See also Revs. 4463, 4465, 4578, 4580, 4584, 4586, 4746, 4965)

4557. Owen, W. S., Averbach, B. L., and Cohen, M., Brittle fracture of mild steel in tension at – 196°C, *Trans. Amer. Soc. Metals* **50,** 634–653, 1958.

Fracture of low-carbon steel specimens was observed with some strain and microcracks before brittle fracture. Experiment was to be critical with respect to dislocation pile-up theory of Stroh and an interpretation of Griffith-Orowan theory by Low. Author claims only Low theory was compatible with observations, but this claim is not accepted in written discussion [G. Schoech and E. T. Wessel, *Trans. Amer. Soc. Metals* **50;** 653–655, 1958] where it is stated that theories are compatible with different phenomena of authors' experiment.

A. G. Holms, USA

4558. Irwin, G. R., Kies, J. A., and Smith, H. L., Fracture strengths relative to onset and arrest of crack propagation, *Proc. Amer. Soc. Test. Mat.* **58,** 640–660, 1958.

The conditions of stress which control spreading of a deeply embedded tensile crack are essentially those of plane strain. If the thickness of a plate containing a through crack is small enough, crack extension is accompanied by substantial amounts of plastic thickness reduction at the leading edge of the crack. A generalized plane-stress viewpoint is then applicable, and a relatively tough shear mode of fracture occurs. Methods have been developed for duplicating both the plane-strain and plane-stress conditions in laboratory measurements of fracture strength G_c.

Observations of fracture mode, coupled with G_c measurements, suggest that it may be possible to predict which fracture mode will occur in terms of the plate thickness, yield stress, and the value of G_c for completely plane-strain fracturing. The relationship thus outlined appears to be in agreement with the observed ductile-brittle fracture transition of low-carbon structural steel with reduction of temperature or with increase of stress loading speed.

Measurements of G_c, coupled with stress analysis and estimates of starting crack size, assist the analysis of important problems—for example, fracture of pressurized fuselage of commercial jet aircraft, bursting of large steam turbine-generator rotors, structural vulnerability of combat airplanes, shattering of transparent plastic canopies, and crack propagation in rocket engine vessels.

From authors' summary by F. Garofalo, USA

4559. Kolsky, H., and Shi, Y. Y., Fractures produced by stress pulse in glass-like solids, *Proc. Phys. Soc. Lond.* **72,** 447–453, 1958.

Sudden impulses were applied by means of small explosive charges to one end of rods of glass, polystyrene, and polymethylmethacrylate. Stress amplitudes were calculated from displacement-time curves at other end of rods. Displacements were measured by a variable-capacitance device. Maximum amplitudes of tensile stresses produced upon reflection at far end of rods were determined, which could be transmitted without fracture. Results were compared with static fracture tests in tension. Authors observe that loading times in the order of micro-seconds raised the fracture strengths of all three materials to about twice of those observed in static tests. Findings were not interpreted in terms of possible fracture mechanisms.

F. R. Brotzen, USA

4560. Collins, R. D., Jr., and Kinard, W. H., The dependency of penetration on the momentum per unit area of the impacting projectile and the resistance of materials to penetration, NASA TN D-238, 41 pp., May 1960.

The dependence of projectile penetration in semi-infinite solid targets has been investigated for targets and projectiles of steel, aluminum, copper, and lead. This selection of materials provided 16 different projectile-target material combinations. The penetration data have been presented as a function of the maximum momentum per unit area of the projectile and the crater volumes as a function of the kinetic energy possessed by the projectile. Linear relationships were obtained which adequately predict the crater effects resulting from high-velocity impacts for 12 of the 16 projectile-target combinations. Projectile penetration into lead targets failed to follow a linear relationship with projectile momentum per unit area. From authors' summary

4561. Mayfield, E. B., and Rogers, J. W., Cratering and shock wave phenomena in steel plates at high impact speeds, *J. Appl. Phys.* **31**, 3, 472-473, Mar. 1960.

The impact of aluminum projectiles on steel plates for impact velocities of 2500 m/sec to 3000 m/sec and about 1100 m/sec was studied. Crater volume and penetration were measured. Shock-wave velocity from the free surface was determined and the particle velocity calculated. For annealed 4130 steel plates impacted at 2750 m/sec average velocity, the average free surface particle velocity was 0.205 mm/μsec. Existing theory on cratering and penetration gave excellent agreement with the observed values. From authors' summary

4562. Heneghan, P. S., Some observations of phenomena related to penetrant detection of cracks, *Nondestructive Testing* **18**, 2, 121-123, Mar./Apr. 1960.

The method of penetrant detection of cracks is widely used, but there is little understanding of how the process works. Some related observations and conclusions, which may contribute to the understanding of the process, are made as a result of experimental observations. The cleaning fluid used appears to push oil further into a crack, leaving space for the penetrant to enter. A wet developer appears superior to dry loose powder, which contracts and cracks, thus practically stopping its own ability to absorb. Movement of penetrant oil in a crack is probably in the plane of the crack, allowing for much greater facility of movement of oil in a fine crack than had previously been supposed. From author's summary

4563. Chiarito, P. T., Morgan, W. C., and Morse, C. R., Experimental determination of the temperature and dynamic-strain environment of a tubular combustor liner in a turbojet engine, NASA TN D-204, 33 pp., Mar. 1960.

Data are presented on some of the environmental factors that must be understood in order to identify the failure mechanism involved in the frequent cracking of liners. Metal temperature was not influenced appreciably by hot starts or shutdown procedure. A peak thermal gradient of 1,500 F/in. was measured near a cooling louver at rated speed. Vibratory frequencies between 4,000 and 10,500 cycles per second were attributed to the last five compressor rotor stages. Although the maximum dynamic stress measured as an average value over the area covered by the strain gage was small, peak dynamic localized stresses might exceed the fatigue strength of the sheet material during the service life of the liner. This stress level could probably be lowered by reducing the excitation amplitudes or by increasing the damping in the liner. From authors' summary

4564. Coffin, L. F., Jr., A mechanism for nonprogapating fatigue cracks, *Proc. Amer. Soc. Test. Mat.* **58**, 570-575, 1958.

The author recalls the results of tests conducted by Frost and by Fenner, Owen and Phillips, dealing with the fact that fatigue cracks formed under certain conditions of stress and geometry will not propagate, and attempts to explain the mechanism responsible for this behavior. Essentially his theory states that nonpropagating cracks are due to the ability of the crack to close-up when the tensile stress is reversed into compression, and to transmit in this way compressive stress without stress concentration. The cyclic state of stress at the tip of the crack is more favorable than the one starting the crack at the bottom of the notch. The author ends his paper with important considerations on the significance of residual stresses applied to surface layers as barriers in the way of propagating cracks. A. J. Durelli, USA

4565. Kawamoto, M., and Nakagawa, T., On the new damage line in the fatigue of materials, Proc. Second Japan Congress on Testing Materials, Kyoto, Japan, Oct. 14-15, 1958; Kyoto, Japan Society for Testing Materials, 1959, 1-4.

Damage defined as $1 - N_f/N_0$ where N_0 cycles at stress σ_n cause failure in virgin specimen, N_f causes failure in specimen previously subjected to N cycles of stress σ. Authors choose σ_n 10% above endurance limit and plot experimental results for three steels. R. N. Arnold, Scotland

4566. Findley, W. N., Mathur, P. N., Szczepanski, E., and Temel, A. O., Energy versus stress theories for combined stress—a fatigue experiment using a rotating disc, Brown Univ., Engng. Materials Res. Lab. 13, Div. Engng. TR-7, 1-19, Dec. 1958.

In order to check the validity of the strain-energy theory for fatigue failure, authors carried out an experiment with a rotating disk specimen of cast aluminum alloy loaded along the diameter to cause stress at the center of the disk where strain energy was maintained constant while the direction of the principal stress was rotating.

The fact that fatigue cracks were developed at the center led authors to the conclusions that fluctuating strain energy could not be the prime cause of fatigue failure, or conversely, fatigue failure must result from fluctuation of some component of stress or strain, and that fatigue criteria of strain-energy form may yield incorrect results outside the range which has been verified by experiment. Y. Hori, Japan

4567. Findley, W. N., Final report on a project entitled "Basic research on fatigue failures under combined stress," Brown Univ., Engng. Materials Res. Lab. 13, Div. Engng. TR-7, 20-24, Dec. 1958.

Paper is a collection of summaries of the following reports which, together with preceding review, constitute a complete report on extensive studies on fatigue failures under combined stress by author et al. Reports no. 3 and no. 6 were reviewed in previous issues of AMR.

Technical Report no. 1. "Theory for combined bending and torsion fatigue with data for SAE 4340 Steel," by W. N. Findley, J. J. Coleman, and B. C. Hanley, EMRL-4, April 1956.

Technical Report no. 2. "Theories relating to fatigue of materials under combinations of stress," by W. N. Findley, EMRL-2, June 1956.

Technical Report no. 3. "Fatigue of metals under combinations of stress," by W. N. Findley, EMRL-3, June 1956. [AMR **10**(1957), Rev. 4031].

Technical Report no. 4. "A theory of the non-linear influence of normal stress on fatigue under combined stresses," by J. J. Coleman and W. N. Findley, EMRL-5, November 1956.

Technical Report no. 5. "A statistical method for determining fatigue strengths with a limited number of specimens," by J. J. Coleman and W. N. Findley, EMRL-9, June 1957.

Technical Report No.6. "A theory for the effect of mean stress on fatigue of metals under combined torsion and axial load or bending," by W. N. Findley, EMRL-12, March 1958 [AMR **12**(1959), Rev. 2919.]
Y. Hori, Japan

4568. Shuvalov, S. A., Endurance of machine parts under variable load conditions and accumulated damage due to fatigue (in Russian), *Vestnik Mash.* **39,** 5, 3–9, May 1959.

Fatigue life is defined as $\int dn_i/N_i = a$, n_i being the number of loadings at a certain stress level σ_i and N_i the ultimate number of cycles at that level. The value of a depends on the nature of the amplitude distribution of the load. By means of a testing machine (described in earlier papers not available to reviewer) author can generate load cycles of n_μ periods according to:
$n_i = n_{\mu/2}\,\{(P_i - P_{\min})/(P_{\max} - P_{\min})\}^a$, in which the power a is varied between 0.2 and 2.

Defining σ_0 as the ultimate fatigue strength for indefinite life and investigating steel types with Brinell hardnesses ranging from 200–300 kg/mm² a great number of fatigue tests are performed with a, $\sigma_{\max}/\sigma_0$ and $\sigma_{\min}/\sigma_0$ as parameters.

The results are discussed and some practical considerations for the machine designer are included. Paper forms part of a series and is somewhat difficult to read separately.
R. G. Boiten, Holland

4569. Munse, W. H., Evaluation of laboratory fatigue studies for welded structures, *Welding J.* **39,** 4, 172s–175s, Apr. 1960.

Discussion indicates how laboratory data can be used effectively to predict the behavior of welded structures subjected to repeated loads.
From author's summary

4570. Sorensen, S. V., and Kozlov, L. A., Linear interpretation of cumulative damage and resistance characteristics to fatigue and stress rupture (Long-time static destruction), *Indust. Lab.* **24,** 11, 1506–1521, Nov. 1958. (Translation of *Zavod. Lab.* **24,** 11, 1378–1391, Dec. 1959 by Instrument Society of America, Pittsburgh 22, Pa.)

Fatigue and stress-rupture curves in log coordinates (constant parameter-temperature) and temperature-life curves (constant parameter-stress) can be depicted by straight-line segments, the slope of which determines the value for the exponent in the equation of the curve and characterizes resistance to fatigue and rupture.

Fatigue and stress-rupture curves for repeated mechanical and thermal overloads on log coordinated log $[z_2/(Z_1 - z_1)]$ vs log (x_2/x_1) are also depicted by straight-line segments, the slope of which determines the value of the exponent q in the equation of the curve and characterizes resistance to repeated cyclic overloads, both mechanical and thermal.

Under repeated overloads the resistance to fatigue is characterized by the constant value of q in the limits of the stress-amplitude ratio from 1 to $(\sigma_2/\sigma_1)_0$, characteristic for a given material. When $\sigma_2/\sigma_1 > (\sigma_2/\sigma_1)_0$, the summation of damages approaches the simple linear one, $\Sigma(n/N) = 1$.

In order to determine resistance characteristic to repeated mechanical and thermal overloading, it is necessary to determine primary fatigue or stress-rupture curves under stationary conditions and secondary curves under overstressing or overheating, then determine characteristic terms p and q, and finally compare the two.
From authors' summary

4571. Ivanova, V. S., and Gordienko, L. K., Determination of the limit of fatigue (in Russian), *Zavod. Lab.* **23,** 12, 1489–1491, 1957; *Ref.-Zh. Mekh.* no. 2, 1959, Rev. 2061.

It is proposed to accelerate the determination of the limit of endurance of a metal by using I.A. Oding's equations for the fatigue curve [*Dokladi Akad. Nauk SSSR (N.S.)* **105,** 6, 1238–1240, 1955] and also Weibull's [W. W. Weibull, *Trans. Roy. Inst. Technol. Stockholm* p. 271, 1959]. The magnitude of the limit of fatigue σ_ω should ensure the rectilinearity of the fatigue curve coordinates $\lg(\sigma_i - \sigma_\omega)$ and $\lg N_i$, where σ_i is the stress-producing fracture in N_i cycles. The application of the method is demonstrated by examples of the determination of the limit of fatigue on Armco-iron and on cold-hardened aluminum.
E. K. Ashkenazi
Courtesy Referativnyi Zhurnal, USSR

4572. Kawamoto, M., Magari, S., and Nakagawa, T., Electron microscopic study of the fatigue fracture of steel, Proc. Second Japan Congress on Testing Materials, Kyoto, Japan, Oct. 14–15, 1958; Japan Society for Testing Materials, Kyoto, 1959, 5–9.

4573. Lewis, W. C., Design considerations for fatigue in timber structures, *Proc. Amer. Soc. Civ. Engrs.* **86,** ST 5 (*J. Struct. Div.*), 15–23, May 1960.

Experimental Stress Analysis

(See also Revs. 4403, 4471, 4500, 4610, 4792, 4960)

4574. Gerard, G., and Tramposch, H., Photothermoelastic investigation of transient thermal stresses in a multiweb wing structure, *J. Aero/Space Sci.* **26,** 12, 783–786, Dec. 1959.

Paper presents results of experimental stress analysis of a long wing model using photothermoelastic technique previously discussed [see AMR **10**(1957), Rev. 61] and described briefly in present paper. Experimentally determined stresses are shown to be less at critical locations than those predicted by an available theory, the discrepancy being ascribed mainly to use of a one-dimensional heat-transfer analysis of the flanges. Good agreement is obtained, however, when experimentally measured temperatures are used as basis of stress calculation, leading authors to suggest use of two-dimensional heat-conduction analysis for thick flanges.
J. E. Goldberg, USA

4575. Krenzke, M. A., Hydrostatic tests of conical reducers between cylinders with and without stiffeners at the cone-cylinder junctures, David W. Taylor Mod. Basin Rep. 1187, 21 pp., Feb. 1959.

A description is given of hydrostatic load tests on conical reducers joining two cylinders of different radius. The object of the work is twofold: (a) to determine the collapse pressure of such a reducer in the absence of hoop stiffeners at the reducer-cylinder junctions and (b) to investigate the effect of the presence of such stiffeners on the mode of collapse and the collapse pressure. Tests indicate that yielding always occurs at the larger juncture appreciably below collapse pressure; for models without stiffeners yielding next occurs at the smaller juncture; but for models with stiffeners, this yielding occurs between one third and one half of the distance to the larger end. It is also shown that collapse pressure can be increased considerably by the presence of stiffeners at the junctions. A design procedure for cone-cylinder junctions is given on the basis that optimum design allows no rotation of the stiffener at the junction.
R. T. Severn, England

4576. Laurent, P., Tran-Xuan-Thoai, and Altmeyer, G., Contribution to the complete determination of the state of residual stresses in metallic hollow cylinders (in German), *Forsch. Geb. Ing. Wes.* **25,** 2, 44–54, 1959.

Authors apply the formulas of G. Sachs to calculate residual stresses in cylinders which have been quenched after annealing. First they used electrical strain-gage measurements of outer or inner surface strains accompanying stress release brought about by

boring out or turning off successive layers. Later they developed an alternative procedure in which, after the boring-out process has been carried to a certain wall thickness, small test pieces on which longitudinal and tangential gages have been cemented are cut from the outer layer, thus releasing the local residual stress. The surface data so obtained permits interpolation with the data from the boring-out process instead of less accurate extrapolation. Results of this interpolation agreed satisfactorily with some tests using the combined boring-out and turning-off procedures. They found that their variations of annealing temperature had little influence on the residual stresses. A derivation of the Sachs formulas is presented. L. E. Malvern, England

Material Test Techniques

(See also Revs. 4463, 4465, 5422, 4541, 4556, 4557, 4565, 4568, 4570, 4571, 4572, 4595, 4600, 4605, 4961, 4962)

4577. Weibull, W., The dependence of strength on the sample size (in German), *Ing.-Arch.* **28,** 360–362, Mar. 1959.

The general equation is given for the probability of nonoccurence of a fault in test specimen and of an event in a test. The general condition of random occurence of either an event in a test or a fault in a test specimen is not always applicable. The application of the general equation to the tensile testing is given with particular attention to the influence of testing method and equipment. The equation is considered true for crystalline-natured materials and explains the reason why smaller test specimens are giving better results. The proof of the equations in the case of large molecule materials—artificial yarns—is given as the analysis of the set of tensile results on yarn. Two examples are also given from mechanical testing of steel to illustrate how the influence of test equipment on final results could be checked.

W. de O'Byrn, England

4578. Zilova, T. K., Petrukhina, N. I., and Fridman, Ya. B., Regarding the laws of the kinetics of deformation as a function of the compliance of loading, *Soviet Phys.-Doklady* **4,** 1, 210–213, Aug. 1959. (Translation of *Dokladi Akad. Nauk SSSR (N.S.)* **124,** 6, 1236–1239, Jan./Feb. 1959 by Amer. Inst. Phys., Inc., New York, N. Y.)

Author discusses tension tests on steel and aluminum rods during which the rate of increase in load and the duration of predetermined peak load are varied. Neither the machine used for loading nor the system used for measuring force and deformation versus time are described.

The author does show several curves of force and deformation versus time. Based on only a few tests, author reaches the general conclusion that fracture depends on rate of increase of load, peak value of load, and the duration of this peak value.

R. Dove, USA

4579. Higuchi, M., On the strength properties of Kraft paper, *Rep. Res. Inst. Appl. Mech., Kyusbu Univ.* **7,** 25, 63–68 (Note), 1959.

Compression tests on kraft paper bags containing potato starch and extension tests on a paper specimen taken from the broken bags were made by author. For the compression test, three or four bags containing 22.5 kg potato starch and piled on each other were pressed with an universal testing machine; the load-compression curves were recorded.

As the collapse of the bags generally occurred at the faces of two bags in contact and not at the seams, a number of small-sized bags, of geometrically similar form (reduction scale 1/100 in capacity) with strong seams, were prepared and submitted to testing. The broken specimens showed a longitudinal tear in the center of the contact faces of the bags; it was concluded that the paper is not subjected to hydrostatic pressure but is stretched by the frictional force between paper and contents; this was confirmed by tests on slick paper bags which broke at their side along the length.

The load-deformation curves of the small-sized bags are quite similar to those of the larger ones and the breaking load was roughly reduced in the proportion of the cubic root of the capacity reduction (1/100).

These results can be interpreted in two ways: (1) approximately, the breaking load is proportional to the face area ($100^{2/3}$) and inversely proportional to the depth ($100^{1/3}$) of the bag, the extension of the paper being roughly proportional to the depth; (2) the bag bursts as subjected to hydrostatic pressure. Tests have shown that this latter occurs only in the case of small friction between paper and contents.

For the extension tests, which were made on new and broken bags, it was shown that, for the latter, considerable reduction in strength along the fiber direction and a decrease in extension across the fiber direction occur. It must be noted that the faces in contact with the rigid plates show less decrease in strength and in extensibility than the faces between bags.

Extension tests on paper specimens having different water contents were made; they show the decrease in strength with water content. D. De Meulemeester, Belgium

4580. Breindel, W. W., Seale, C. L., and Carlson, R. L., Evaluation of a single-shear specimen for sheet material, *Proc. Amer. Soc. Test. Mat.* **58,** 862–868, 1958.

Results on a comprehensive evaluation of a "single-shear" specimen for determining the ultimate shear strength of sheet materials are given. Three possible modes of failure (shear, tearing, and buckling) are described. Relative specimen dimensions determined experimentally to be necessary to produce the desired shear failure are shown.

Emphasis on a "simple" test to obtain limited material property information is refreshing. R. L. Bloss, USA

4581. Kurbatov, V. M., Device for measuring small deformations during compression tests on rock samples, *Indust. Lab.* **24,** 10, 1407–1408, Nov. 1959. (Translation of *Zavod. Lab., USSR* **24,** 10, 1274–1275, Oct. 1958 by Instrument Society of America, Pittsburgh 22, Pa.)

4582. Moore, T. G., and Opersteny, E. J., Static testing high-pressure piping components, *ASME Trans.* **82** B (*J. Engng. Indust.*), 1, 15–22, Feb. 1960.

A method for testing high-pressure piping systems for service in the 20,000 to 40,000-psi range is described. Tubing systems were pressure tested and their behavior followed by means of resistance-wire strain gages mounted on the exterior surface. A method is described for graphically determining the pressure at which a tube wall becomes fully plastic. The allowable working pressure of a tube is determined by applying a safety factor to this pressure. Tubing bends and fittings, including metal gaskets, flanges, and tees, are evaluated by comparing their behavior under pressure with that of the tube with which they are to be used.

From authors' summary

4583. Danilov, T. L., Ivanov, A. P., Kroshkin, A. A., Razov, I. A., Shevandin, E. M., and Shimelevich, I. L., Bending tests of a wide specimen as an estimate of metal deformability, *Indust. Lab.* **24,** 10, 1365–1367, Nov. 1959. (Translation of *Zavod. Lab., USSR* **24,** 10, 1233–1235, Oct. 1958 by Instrument Society of America, Pittsburgh 22, Pa.)

4584. Geminov, V. N., On the statistical processing of test data on long-time strength, *Indust. Lab.* **25,** 1, 95–100, Mar. 1960. (Translation of *Zavod. Lab., USSR* **25,** 1, 90–94, Jan. 1959 by Instrument Society of America, Pittsburgh 22, Pa.)

For processing the test data and plotting the long-time strength curves it is necessary, in addition to the determination of the most probable mean curve, to find the width of the confidence interval. The mean-square deviation $\overline{S}$ can be conveniently used as the initial calculation characteristic. The width of the confidence interval found from the data obtained from a limited number of test points is larger than the width of the "ideal" confidence interval which is obtained from an infinite number of points. The width of the confidence interval increases as the extrapolation proceeds; this increase is the greater the bigger the relative length of the extrapolation section. The width of the confidence interval and its increase during the extrapolation decrease with the increasing number of test points. The rate of decrease of the confidence interval is highest up to about 15 specimens.

It can be assumed that the distribution of test points over the interval being examined is uniform, or in groups of several points on each level. For example, in experiments concerned with the long-time strength, one specimen can be tested for each of 12–15 stress levels or 2–3 specimens at each of 5–6 stress levels.

From author's summary

4585. Shorin, A. V., A multi-sample machine for high-temperature endurance testing (in Russian), Izzled. po zharoprochm. splavam, Vol. 2, Moscow, Akad. Nauk SSSR, 1957, 281–284; *Ref. Zh. Mekh.* no. 9, 1958, Rev. 10641.

A machine is described for the simultaneous fatigue endurance testing of six tensile samples with a diameter of 5 mm and a length of 25 mm. The maximum load on each sample is 750 kg, and test temperatures up to 950 C can be applied. An electric furnace with five sections is used. The furnace is maintained at constant temperature, and the temperatures recorded automatically by an electronic potentiometer. A considerable temperature difference between the samples (3–5°) was observed during testing. When changing a failed sample for a new, cold sample the difference was (30–35°) for two adjacent samples, and 7–10° for the three others).

G. A. Tulyakov

Courtesy Referativnyi Zhurnal, USSR

4586. Graf, M. E., and Ruban, P. M., Determination of dynamic errors when testing fatigue in bending, *Indust. Lab.* **24,** 11, 1532–1535, Nov. 1958. (Translation of *Zavod. Lab.* **24,** 11, 1407–1408, Dec. 1959 by Instrument Society of America, Pittsburgh 22, Pa.)

In machines for testing bending, as well as in those for testing tension and compression, and also twisting, the value of the dynamic error is independent of the method of driving, the driving load or the mass of the drive. This fact provides the possibility of selecting a driving mass for an optimum power condition of operation. As distinct from machines testing tension and compression, and also twisting where the dynamic error is affected only by the stiffness of the dynamometer and the mass of the clamp related to it (out of the elements of the system), in machines for testing bending, the dynamic error depends on the stiffness of all the elements of the system and on all the lumped masses (with the exception of that of the drive).

In actual tests of fatigue, where fixing conditions often require an increase in the size and weight of clamps, it is necessary to remember that an increase in the mass of the clamps leads to a rapid rise in the dynamic error. An especially rapid rise of the dynamic error is experienced if the mass of the clamp nearest to the drive is increased.

The relationships thus obtained provide a sufficiently accurate calculation of the dynamic error and a selection of optimum dynamic parameters for the testing machines used.

From authors' summary

4587. Getsov, L. B., Methods of testing thermally stable materials under conditions of variable temperature and stress, *Indust. Lab.* **24,** 10, 1378–1382, Nov. 1959. (Translation of *Zavod. Lab., USSR* **24,** 10, 1247–1251, Oct. 1958 by Instrument of Society of America, Pittsburgh 22, Pa.)

4588. Kataev, G. I., Apparatus for measuring with greater accuracy the dependence of elastic moduli and damping decrement on temperature, *Indust. Lab.* **24,** 10, 1389–1392, Nov. 1959. (Translation of *Zavod. Lab., USSR* **24,** 10, 1258–1260, Oct. 1958 by Instrument Society of America, Pittsburgh 22, Pa.)

4589. Welsh, N. C., Spark-hardening of metals, *J. Inst. Metals* **88,** 103–111, 1959/60.

The influence of electric sparks on the structure and hardness of metal surfaces has been studied, a vibrating electrode being used to generate the sparks. Each spark fuses a small volume of metal, which rapidly chills when the discharge ceases. Steel surfaces are hardened by the thermal cycling, but evidence is given that elements derived from the sparking medium accentuate the hardness change. Thus, nitrogen from the atmosphere or carbon from an oil promote hardening even in pure iron. The same elements confer great hardness on metals such as titanium and zirconium, which react chemically to form hard compounds. Surface alloying also occurs by the transfer of matter between the sparking contacts, and experiments with sintered-carbide electrodes show that very hard, wear-resistant layers can be formed on most engineering metals. Spark treatment has been successfully developed in Russia as a practical process for hard-surfacing steel, and wear tests carried out in the present work indicate its potential value in the non-ferrous metals field.

From author's summary

4590. Orner, G. M., and Hartbower, C. E., Notch sensitivity in high-strength sheet materials, *Welding J.* **39,** 4, 147s–159s, Apr. 1960.

Notch sensitivity in high-strength sheet and several techniques used for its measurement are discussed. The Charpy test, using standard V-notch test specimens (except for width which is made equal to sheet thickness) is indicated to be a highly informative and economical test for notch sensitivity in sheet in thicknesses not less than approximately 0.040 in.

A correlation between Charpy energy, adjusted for sheet thickness, and critical elastic-energy release rate (G_c) is demonstrated for tough and moderately tough sheet materials. In brittle materials, anomalous results were observed. The probable reason for these anomalies is suggested. Correlation is also demonstrated between critical crack length (at the 0.2% yield stress) and Charpy "notch-toughness index," a parameter derived from Charpy energy-to-fracture adjusted for sheet thickness, yield strength and modulus. Formulas are derived for obtaining approximate values for G_c and critical crack length directly from Charpy results.

From authors' summary

4591. Gross, J. H., Comparison of Charpy V-notch and drop-weight tests for structural steels, *Welding J.* **39,** 2, 59s–69s, Feb. 1960.

Relationship between nil-ductility transition and various Charpy V-notch transition temperatures, including the 15-mil lateral-expansion transition temperature, is examined.

From author's summary

4592. Binczewski, G. J., The effect of fabrication on inclusion-type defects and their ultrasonic response, *Nondestructive Testing* **18,** 2, 93–98, Mar./Apr. 1960.

Known kinds of inclusion-type defects which might occur in aluminum were investigated and their specific behavior during various stages of fabrication was evaluated ultrasonically and radiograph-

ically. Generally, for ultrasonic inspection conformance purposes, the types of defects commonly encountered in plate products deform in a plastic manner analogous to the parent metal. However, the inherently variable characteristics of any specific defect precludes the ability of the sonic test method to always assure that a given ingot defect will, or will not, result in an ultrasonically acceptable plate. Many defects which cause ultrasonic rejection of finished products are essentially not ultrasonically detectable in the ingot.

From author's summary

4593. Bender, J. H., Jr., Dutli, J. W., and Edwards, P. D., Electrode potential testing, *Nondestructive Testing* **18,** 2, 99–102, Mar./Apr. 1960.

This paper describes the development and some applications of a nondestructive test for ionic surface inclusions in metals, and for pores through an electroplate or cladding. The principle upon which this test method is based involves the electrode potential difference that exits between dissimilar ionic materials when immersed in a suitable electrolyte. The so-called "local action" that takes place in the vicinity of an inclusion or pore produces an electric field with considerable spatial distribution which may be rather easily detected. From authors' summary

4594. Trout, O. F., Jr., Exploratory investigation of several coated and uncoated metal, refractory, and graphite models in a 3800° F stagnation temperature air jet, NASA TN D-190, 73 pp., Feb. 1960.

Hot air jet tests were made on models of molybdenum coated with chromium plating, chromium-nickel plating, Chromalloy W-2, nickel aluminide, molybdenum disilicide, zirconia molybdenum laminate, and alumina molybdenum laminate; models of various grades of graphite, silicon carbide bonded graphite, siliconized graphite, and graphite coated with chrome plating, zirconia molybdenum laminate, and alumina molydbenum laminate; ceramic models of titanium boride, silicon carbide, zirconium boride, siliconized boron, and phosphate bonded alumina chromia ceramic reinforced with molybdenum wire. A description of the tests and the results thereof are provided.

From author's summary

Properties of Engineering Materials

(See also Revs. 4463, 4465, 4468, 4510, 4535, 4546, 4553, 4556, 4557, 4558, 4559, 4565, 4577, 4589, 4803, 4807, 4812, 4900, 4964)

4595. Pogodina-Alekseeva, K. M., and Krotkova, E. E., Use of the method of microhardness for determining the hardening of structural steel by cold working and strain aging, *Indust. Lab.* **24,** 4, 532–534, June 1959. (Translation of *Zavod. Lab., USSR* **24,** 4, 470–472, Apr. 1958 by Instrument Society of America, Pittsburgh 22, Pa.)

Authors claim that it is necessary to determine microhardness numbers both of the center and the boundary material of the metal grain for different grain sizes if correct conclusions upon the effect of cold working and strain aging of a technical alloy are to be drawn. Paper describes a method used for studying the effects of preliminary deformation by static and dynamic reduction of structural steels. Different aging treatments were chosen, among them aging at normal room temperature during a rather long time (2000 hours). Test results from authors' investigation are presented to show the relevancy of their method.

R. Nilson, Sweden

4596. Tsyganok, N. F., The influence of grain size in steels on the development of stresses of orders II and III during static and dynamic deformation (in Russian), *Ucb. Zap. Shakhtinsk. Gos. Ped. In-ta* **2,** 3, 19–32, 1958; *Ref. Zh. Mekh.* no. 2, 1959, Rev. 2051.

Examinations were made of large-grained steel type 3 and of fine-grained steel type $55C_2$. It was established that both static and dynamic deformation results in an increase in stresses of orders II and III in the early stages of deformation of 15–20%; with further deformation the growth of stresses ceases. It was shown that for large-grained steel type 3 the dynamic deformation produces a smaller increase in stresses of the II^d and III^d order in comparison with the static, which can be explained by the fact that the stresses due to dynamic deformation are partially removed because of the heat separating out. For the steel type $55C_2$ the character of the change of stresses of orders II and III is analogous to that of steel type 3; however the differences between the static and dynamic deformations were not investigated further because of the increased surface energy of the grains.

G. A. Tulyakov

Courtesy Referativnyi Zhurnal, USSR

4597. Vanderbeck, R. W., and Phelps, E. H., Iron, carbon steel, and alloy steel, *Indust. Engng. Chem.* **51,** 9 (part 2), 1178–1184, Sept. 1959.

4598. Ohara, H., and Doi, T., Creep on Ni-Ti alloy wire, Proc. Second Japan Congress on Testing Materials, Kyoto, Japan, Oct. 14–15, 1958; Japan Society for Testing Materials, Kyoto, 1959, 47–49.

Thin wires, electrically heated, were tested between 800° to 1340°C. Titanium addition up to 8% show a minimum creep rate at about 4%. Reviewer believes more metallographic work is needed on second phase formation grain size effects and impurity effects to draw valid conclusions. F. Forscher, USA

4599. Koranyi, I., Conditions influencing limit stress of steel type St. 37 (in German), *Acta Techn., Acad. Sci. Hungaricae, Budapest* **26,** 1/2, 135–151, 1959.

4600. Fenn, R. W., Jr., and Gusack, J. A., Effect of strain rate and temperature on the strength of magnesium alloys, *Proc. Amer. Soc. Test. Mat.* **58,** 685–696, 1958.

This paper is a discussion of effect of strain rate (0.005, 0.050, 0.50 and 5.0 per minute) on the strength of several rolled, extruded and cast magnesium alloys at temperatures from 75 to 900° F. It contains a description of the test methods and a tabulation of test data. The authors conclude that significant differences in the indicated strength of magnesium alloys result from variations in testing speed. For that reason, strain rate should be controlled to obtain consistent test results. W. C. Aber, USA

4601. Fenn, R. W., Jr., Young's modulus of magnesium alloys as a function of temperature and metallurgical variables, *Proc. Amer. Soc. Test. Mat.* **58,** 826–840, 1958.

This paper is a discussion of Young's modulus values of several commercial and experimental magnesium alloys at room temperature and at elevated temperatures by static strain measurement. The author states that there are significant variations in Young's modulus of magnesium alloys at elevated temperatures which can be correlated with composition, grain size, prior cold work and heat treatment. He concludes that considerable control of elevated-temperature modulus values of magnesium alloys can be obtained by control of the metallurgical variables and alloying constituents.

The method used for precise determination of Young's modulus is not described in detail, but reference is made to a previous paper for that information. W. C. Aber, USA

4602. Manning, C. R., Jr., Application of rate-temperature parameters to tensile data for magnesium alloys and a relation between the Larson-Miller constant and the activation energy, NASA TN D-172, 23 pp., May 1960.

The Larson-Miller and Dorn rate-temperature parameters were successfully applied to published data to take into account the effect of strain rate and temperature on tensile properties of six magnesium alloys at strain rates from 0.005 minute^{-1} to 5.0 minute^{-1} and temperatures to 800°F. The values of the Larson-Miller constant and the activation energy used in the Dorn parameter were determined for each material. A relation between the values of the Larson-Miller constant and the activation energy was determined for magnesium and aluminum alloys.

From author's summary

4603. Duwez, P., Problems in heat-resisting materials for high-speed flight and propulsion, Advances in Aeronautical Sciences, Vol. 2 (Proc. of the First International Congress in the Aeronautical Sciences, Madrid, Sept. 8–13, 1958), Pergamon Press, 1959, 961–967.

4604. Oliver, D. A., Heat resistant materials: a survey of some British developments, Advances in Aeronautical Sciences, Vol. 2 (Proc. of the First International Congress in the Aeronautical Sciences, Madrid, Dept. 8–13, 1958), Pergamon Press, 1959, 968–989.

4605. Lisitsyn, V. D., The relation between macro- and micro-hardness of metals (in Russian), *Zavod. Lab.* **24,** 4, 467–470, 1958; *Ref. Zh. Mekh.* no. 2, 1959, Rev. 2048.

Lines of equal hardness (isoscleres) are plotted in accordance with results obtained experimentally for various metals. It was established that the stepped principle of similarity $P = ad^n$ with $n = 2$ is true for a fairly wide range of loadings. For tempered homogeneous alloys with a diagonal of the impression greater than 30μ the values for the macro- and micro-hardnesses are practically the same. For heterogeneous alloys the value $n = 2$ can be accepted as approximately true. In the case of deformed alloys, analogous relations are examined, but here it was found that the magnitude of the transpositions of the isocleres of heterogeneous materials decreased with increase in the extent of deformation.

G. A. Tulyakov

Courtesy Referativnyi Zhurnal, USSR

4606. Rivello, R. M., Ramberg-Osgood and Hill parameters of aircraft structural materials at elevated temperatures, Univ. Maryland, Dept. Aero. Engng. Rep. 60–1, 32 pp., Mar. 1960.

The Ramberg-Osgood and Hill parameters which give analytic descriptions of the stress-strain curve are determined at elevated temperature for several aircraft and missile structural materials. Curves are given for the variation of these parameters with temperature for the more commonly used alloys of aluminum, magnesium, steel, inconel, and titanium. The data which are for short-time exposure to elevated temperature (1/2 hour exposure before testing at a strain rate of approximately 0.002 per minute) were computed from elevated temperature stress-strain curves which have been previously published by others.

From author's summary

4607. Lang, S. M., Properties of high-temperature ceramics and cermets—Elasticity and density at room temperature, Nat. Bur. Stands. Monograph 6, 45 pp., Mar. 1960.

In order to provide some of the basic data necessary for the effective utilization of ceramics and cermets in various high-temperature applications, a specimen "bank" of such materials, mainly commercially fabricated, was established for the measurement of physical properties and constants. This Monograph describes: (1) The materials and some of their fabrication data; (2) bulk densities; (3) theoretical densities; and (4) the dynamic room-temperature elastic constants. Data are given for 46 sets of specimens, representing 20 different materials; these include oxides, carbides, borides, cermets, and an intermetallic compound. A statistical evaluation was used for analyzing the data.

Results of the room-temperature measurements show that: (1) Significant variations are common both in the specimens of one group and from group to group of specimens prepared of the same material; (2) the largest variations occur for specimens formed by hot-pressing, although average values are higher for hot-pressed specimens; and (3) measurements of the dynamic elastic constants by the sonic method are more sensitive as indicators of homogeneity and group uniformity than bulk-density measurements.

From author's summary

4608. Stiehler, R. D., Steel, M. N., Richey, G. G., Mandel, J., and Hobbs, R. H., Power loss and operating temperature of tires, *J. Res., Nat. Bur. Stands.* **64C** (*Engng. and Instrum.*), 1, 1–11, Jan.–Mar. 1960.

The power loss of pneumatic tires was measured under steady-state conditions by means of two dynamometers, one of which measured the total power input and the other power output. A steel wheel was used to measure the power loss in the equipment and in windage. The power required to flex the tire (input power minus output power minus equipment and windage losses) was not affected by the tractive effort (output power). The coefficient of rolling resistance, a dimensionless quantity, was calculated by means of the equation: $R = (P/SL)$, where P is power loss of tire, S is speed, and L is load. This coefficient increased at an increasing rate with the slip angle (angle between plane of tire and direction of travel) and was approximately doubled at an angle of 2 degrees.

The type of rubber had a pronounced effect on R and combinations of natural and styrene-butadiene rubber caused R to be larger than expected from the values of R for tires made from a single rubber.

The temperature rise of the air in the inner tube was found to be related to the power loss by the relation: $\Delta T/P = G + H/(SL)^{0.8}$ where G and H are parameters dependent on the thermal resistance of the rubber compounds and of the interface between tire and air or roadway, respectively. The ratio $\Delta T/P$ remained essentially unchanged by changes in inflation pressure and did not appear to be affected by the type of cord.

From authors' summary

4609. Wentorf, R. H., Jr., Note on the scratching of diamond, *J. Appl. Phys.* **30,** 11, 1765–1768, Nov. 1959.

The hardness of diamond varies at its different crystallographic planes. In diamond cutting, the surface to be cut and the cutter have almost the same hardness, but the surface has the advantage of being supported by neighboring material through a large angle of 180° while the cutter has only a small angle subtended by the neighboring material. The surface being cut is obviously stronger than the cutter. Thus, the mechanism of diamond-cutting or scratching must be different from the usual way of cutting materials.

Diamond is weak in tension and thus fails under tensile stress. During scratching the tensile stress in the diamond surface behind the scratching particle is larger than that in the leading edge of the cutter. Thus, cutting diamond is equivalent to tearing the surface of a gelatine dessert by a spoon. But diamond is not isotropic like gelatine; it is weak in tension across octahederal planes or 111 planes. Therefore, the easiest way to polish or scratch diamond would be to tear off fragments bounded by octahederal planes.

Bowdwen et al found that the coefficient of friction varies also on each crystallographic plane of diamond, but the easiest grinding directions are associated with the high coefficient of friction and vice versa. The easiest direction to polish is the direction of x, y, z, axis of a cube and the 001 direction on 110 face.

The application of these theories to the grinding and wear of other material should be done with caution. Attempting to calculate the rates of removal of various diamond forces is important but impractical at present. C. T. Yang, USA

Structures: Simple

(See Revs. 4421, 4489, 4493, 4494, 4496, 4500, 4506, 4507, 4516, 4569, 4933)

Structures: Composite

(See also Revs. 4421, 4499, 4510, 4556, 4575, 4631, 4792, 4901, 4960)

Book—4610. Matz, G., and Gayer, P., Computation of cast iron enameled pressure vessels; measurement performance on a 6m^3 mixing tank [Berechnung von gusseisernen emaillierten Druckbehaltern; Messungen an einem 6 cbm-Ruhrwerksbehalter], Berlin, Springer-Verlag, 1959, xvi + 233 pp. DM 37.50

In chemical plants surface-treated containers are becoming more common and enamel is widely used for protection of the surface. With the increase in size of the containers the behavior of enamel, especially under great pressures, becomes more important, and the investigations described in the present book are thus very timely. A large enameled pressure vessel of cast iron has been subjected to internal pressure, and strains in the enamel and shell have been determined by electric resistance strain gages. The measurements are compared with theoretical estimates based on shell theory, which is believed to be used here for the first time in this connection. In view of the good agreement between theory and observations, the design methods in the latter part of the book, which also deals with the associated thermal stresses, are particularly useful and should result in more rational and economical design. The clear and well-illustrated book is warmly recommended to students and practising engineers in this branch of plant design.

G. G. Meyerhof, Canada

Book—4611. Silberring, L., Calculation of stresses in pipelines [Obliczanie wytrzymalosciowe rurociagow], Warszawa, Panstwowe Wydawnictwa Techniczne, 1959, 133 pp. zl 17. (Paperbound).

Calculations of stresses and displacements in plane and spacial pipeline systems are discussed in detail, in particular in presence of high pressures and temperatures. Steel circular cross sections are considered both in elastic and plastic stress ranges. Book contains useful graphs and tables. Procedures are illustrated with nine worked examples. Short bibliography contains several relatively recent Russian texts.

S. J. Medwadowski, USA

4612. Yoshiki, M., Kanazawa, T., and Ando, F., A study on the strength of ship's bottom platings, Proc. 2nd Congr. Theor. Appl. Mech., New Delhi, India; Indian Soc. Theor. Appl. Mech., Indian Inst. Technol., Kharagpur, 1956, 41–56.

Authors study theoretically the characteristics of continous plates supported by floor beams at constant intervals. Plates are under compressive edge load and a uniform lateral load. The plates were assumed to have small initial stresses and deflections produced by edge moments, caused by welding, which are slightly different in quantities in adjacent panels. The problem is solved by integral equation method.

Investigation shows that the panels may buckle upward and downward alternately when there is difference in initial deflections in the adjacent panels. The theoretical results, which are confirmed by model experiments, are very interesting for shipbuilding practice. V. K. Jojic, Yugoslavia

4613. Argyris, J. H., and Kelsey, S., The analysis of fuselages of arbitrary cross-section and taper, *Aircr. Engng.* **31,** 361, 62–74, Mar. 1959; **31,** 362, 101–112, Apr. 1959; **31,** 363, 133–143, May 1959; **31,** 364, 169–179, June 1959; **31,** 365, 192–203, July 1959; **31,** 366, 244–256, Aug. 1959; **31,** 367, 272–283, Sept. 1959.

This remarkable paper is unusually long and thorough for a journal. It presents a rational method for the structural analysis of stressed skin fuselages for application in conjunction with the digital computer. The theory is a development of the matrix force method which permits a close integration of the analysis and the programming for a computer operating with a matrix interpretive scheme. The structural geometry covered by the analysis is sufficiently arbitrary to include most cases encountered in practice, and allows for nonconical taper, double-cell cross sections and doubly connected rings. A highly standardized procedure is developed which requires as input information only the simplest geometrical and elastic data. An essential feature is the use of the elimination and modification technique subsequent to the main analysis of the regularized structure in which all cutouts have been filled in.

Paper illustrates a special application of the matrix force method developed by Argyris earlier. It illustrates what ease and accuracy can be achieved in handling an extremely complicated problem. The computing logic is made the focus of research. The ease of coding and checking for the machine calculation is achieved.

The analysis provides not only the stress distribution, but also the flexibility matrix which furnishes the starting point for dynamic response and aeroelastic analyses of the airplane.

There are many ideas and details put forward in this paper. It is impossible even to summarize. Perhaps the best introduction to the paper is Argyris's lead article in AMR Vol. 11, no. 7, July 1958: "On the analysis of complex elastic structures."

Paper is strongly recommended for structural engineers.

Y. C. Fung, USA

4614. Alexander, H. R., Structural flexibility and under carriage impact loads—the combination of landing reactions and dynamic stresses, *Aircr. Engng.* **31,** 363, 126–130, May 1959.

Author suggests introduction of aircraft flexibility into equations for under carriage reactions, and outlines general procedure on the basis of frequencies and shapes of the normal modes. He seems unaware of previous exhaustive treatment of same problem by J. P. Bentham [Dutch report NLL—TN S.478, 1956], who shows that not less than the first four (symmetrical) modes need to be considered if reliable results are wanted. Author's suggested approximation based on using fundamental mode alone seems therefore unlikely to be a safe guide to the design of the undercarriage.

D. Williams, England

4615 Broglio, L., Some contributions to the heat conduction and thermal stress analysis in aircraft and missile structures (in Italian), *Aerotecnica* **39,** 2, 53–65, Apr. 1959.

Important problems in designing aircraft and missile structures are closely connected with finding the temperature distribution within the solid, the surface of which is heated kinetically and by radiation. The difficulty of the problem lies in that the parameters of the nonlinear basic relation between the temperature and heat flux at the surface depend not only upon the time but also upon the unknown temperature of the surface. Even in those favorable cases where we know (e.g. from the experiments) the variation of the above parameters, the nonlinear character of the boundary condition makes it impossible to use the classical methods, and integral and transformation methods, as well.

The extraordinary value of Broglio's present paper is that it enables us to solve the question for heterogeneous solids of any shape. This will be achieved by reducing the problem to an integrodifferential equation which can be easily treated by an easily comprehensible step-by-step method.

Paper is divided into three main parts. First comes theoretical foundation of the new method, the following section completes general theory on some advanced special cases, and author concludes with remarkable applications of immediate technical significance. This last section is provided with graphs and numerical tables. V. Vodicka, Czechoslovakia

4616. Preti, E., On the ultimate strength possibilities of a wing structure (in Italian), *Aerotecnica* **38**, 4, 227–233, Aug. 1958.

The possibility is discussed of the spanwise displacement of a plastic hinge created by an overloading in the wing structure. In this way one may avoid the failures caused by dynamic loadings and particularly by the effect of vertical gusts.

The variation of the incidence with time is established, which in case of vertical gusts is given by an exponential law. The shearing force and the bending moment are readily deduced function of the body and aerodynamic forces and then equalized to the corresponding values given by the physico-geometrical properties of the wing cross sections where the plastic hinge occurs. A system of differential equations is obtained, a function of the following parameters: (1) distance from the wing tip; (2) velocity vertical component; and (3) angular rate of deformation.

Trapezoidal and rectangular wings are examined and practical conditions are deduced for improving the behavior of wing structures.

Reviewer believes that paper is useful for the strength calculation of aircraft wings. An experimental verification of the influence of the parameters intervening in calculations would however have augmented its value.

N. S. Tipei, Roumania

Machine Elements and Machine Design

(See also Revs. 4407, 4420, 4434, 4449, 4461, 4568, 4633, 4970)

4617. Hajos, L., Air-cushion springs in road-vehicles (in Hungarian), *Jarmuvek Mezogazdasagi Gepek* **6**, 2, 36–43, Feb. 1959.

In the introductory part, the requirements on spring systems are stated; the characteristics and natural frequency are discussed, as well as the energy storage of piston springs. The main part of the paper is devoted to the description and discussion of various pneumatic springs: both the constant- and variable-volume cushion springs (with and without leveling valves) are discussed with regard to operation characteristics and design and installation features. The hydropneumatic spring systems are also discussed and, finally, rubber springs with cavities are described.

T. P. Torda, USA

4618. Felikson, E. I., Effect of manufacturing errors in dynamometer disc springs on their rigidity, Measurement Techniques no. 4, 422–424, Dec. 1959. (Translation of *Izmeritel'naia Tekhnika, SSSR* no. 4, 34–35, July/Aug. 1958 by Instrument Society of America, Pittsburgh 22, Pa.)

4619. Vermes, A., On the springing of railroad vehicles; Stability of wagons hinged above their center of gravity (in Hungarian), *Jarmuvek Mezogazdasagi Gepek* **6**, 1, 27–32, Jan. 1959.

4620. Kopai-Gora, P. N., Concerning some properties of ferromagnetic clutches, *Automation and Remote Control* **19**, 4, 361–369, Feb. 1959. (Translation of *Avtomatika i Telemekhanika, USSR* **19**, 4, 366–375, Apr. 1958 by Instrument Society of America, Pittsburgh, Pa.).

Ferromagnetic clutches are compared with electric motors and friction and hydraulic clutches in terms of their starting time, electromagnetic time constant, control power, and the ratio of the output moment to the moment of inertia. The said parameters of the ferromagnetic clutches are shown to be better than those of the electric motors and friction clutches.

From author's summary

4621. Maxfield, J. E., and Selfridge, R. G., The surface area of a screw, *Appl. Scient. Res.* (A) **8**, 5, 377–385, 1959.

In this paper formulas are derived for the surface area of a right cylindrical screw having as cross-section edge straight lines and/or circular segments. These formulas involve the nonelementary functions of the incomplete elliptic integral of the first, second and third kinds. These integrals are tabulated in the literature.

From authors' summary

4622. Iwanami, S., Kato, H., and Tikamori, N., Oil leakage from an O-ring packing, *Bull. JSME* **2**, 8, 638–643, Nov. 1959.

Experiments were conducted to find out the behavior of oil leakage from an O-ring packing used for gasket and reciprocating parts. The chief points of the results of this investigation are:

(1) For the gasket: The seals can be made perfectly leakproof for oil pressure up to 280 kg/cm^2 (4000 psi limit of this test pressure).

(2) For the reciprocating use: It has been shown theoretically and proved experimentally that the quantity of oil leakage from an O-ring is proportional to the square of the reciprocating velocity of the rod, the n-th power of the kinematic viscosity of the oil. In this case we have $n \simeq 1$ for the values of ν measured at the working pressure from analytical treatment, but $n = 1.5$ for ν measured at atmospheric pressure from experimental results.

From authors' summary

4623. Adams, D. P., Nomographic synthesis of generator linkages, *ASME Trans.* **82** B (*J. Engng. Indust.*), 1, 29–40, Feb. 1960.

Problem considered is synthesis of four-bar function generating linkage with prescribed range of input and output angles. Using Svoboda's symmetrical formulation of governing kinematic equations, author introduces a new nomogram for finding five remaining linkage parameters. Method is essentially an iterative graphical procedure where one variable at a time is varied until "optimum" values are obtained for linkage dimensions.

B. Paul, USA

4624. Shved, G. L., Reciprocal motion of the geometrical positions of momentary centers of acceleration on a plane figure and on an immovable plane (in Russian), *Trudi Odessk. Technol. In-ta Pisbch. i Kholodil'n. Prom-sti* **8**, 1, 75–88, 1957; *Ref. Zh. Mekh.* no. 2, 1959, Rev. 1130.

By indicating through C, C_1 the geometrical positions of the momentary centers of acceleration in a movable and an immovable plane the author shows that in the general case these two curves have no common tangent. In order to ensure that C and C_1 are mutually enveloping curves it is necessary and sufficient to see that the transferable velocity of the momentary center of acceleration, i.e. the velocity of slide of curve C over curve C_1, shall be a constant as regards magnitude. For this purpose the principle of motion has to conform to a condition such as

$$\frac{C^2}{\omega^2}(\varepsilon^2 + \omega^4) = \left[a_o - \frac{\varepsilon}{\omega} v_o - \omega \times v_o\right]^2$$

where O is an arbitrary pole, v_o, a_o its velocity and acceleration, ω, ε are the angular velocity and acceleration of the plane figure.

Conditions were also found in which curve C or curve C_1 degenerates to a point; the simplest principles of motion are indicated which will satisfy these conditions. Ya. L. Geronimus

Courtesy Referativnyi Zhurnal, USSR

Fastening and Joining Methods

(See Rev. 4500)

Rheology

4625. Mithal, K. G., Motion of a non-Newtonian fluid produced by the uniform rotation of a plate (in English), *Ganita* **9**, 2, 95–117, Dec. 1958.

Author takes stress-rate-of-strain relationship $p_{ik} = 2\mu e_{ik} + 2\mu_c e_{ij} e_{jk} - p\,\delta_{ik}$, where μ and μ_c are constants, and perturbs solution of Karman (1921) for a Newtonian liquid. He cites no liquids for which this stress-rate-of-strain relationship is valid and reviewer regrets that choice is based solely on mathematical tractability. F. M. Leslie, England

4626. Kim, W. K., Hirai, N., Ree, T., and Eyring, H., Theory of non-Newtonian flow, Part III, A method for analyzing non-Newtonian flow curves, *J. Appl. Phys.* **31**, 2, 358–361, Feb. 1960.

See AMR **9** (1956), Revs. 141 and 142.

The historical development of the rate theory of viscosity is briefly reviewed. The Ree-Eyring equation of generalized viscosity,

$$\eta = \sum_{n=1}^{m} (x_n\beta_n/\alpha_n)(\sinh^{-1}\beta_n\dot{S}/\beta_n\dot{S}) \qquad [A]$$

is applied successfully in a variety of cases. A new method is developed for determining the parameters x_n/α_n and β_n in Eq. [A]. According to the method, these parameters are uniquely determined. Using the parameters determined by the new method, the viscosities for solutions of poly-γ-benzyl-l-glutamate were calculated from Eq. [A], which is found to be much superior to other frequently applied viscosity equations.

Upon calculating the Newtonian viscosities η_s for fairly concentrated solutions of polyacrylonitrile and of nitrated pine pulp, the following empirical formula is found:

$$\eta_s \simeq KC^2M\beta_p^{1/2}. \qquad [B]$$

Here K is a characteristic constant for a solution; C the concentration; M the molecular weight; and β_p is the "principal" relaxation time. In dilute solutions, Eq. [B] reduces to the form $\eta_s \simeq K'CM$.

From authors' summary

4627. Tomita, Y., A study on the flow of wood pulp slurries in a pipe line, *Bull. JSME* **2**, 8, 658–662, Nov. 1959.

The flow of wood pulp slurries in pipes is analyzed, making use of data of the author [*Bull. JSME* **2**, 5, p. 10, 1959] and others. At low velocities the flow is treated as that of a Bingham fluid. At higher velocities the flow is comprised of a thin boundary layer of water surrounding a plug of more concentrated slurry. At all velocities the coefficient of friction loss is a function of the dimensionless number $\frac{8\rho_p u_a^2 a}{\tau_y}$, where ρ_p is the pulp density, u_a is the average velocity, a is the relative plug radius, and τ_y is the yield stress. The experimentally observed decrease of friction with velocity at velocities from 2 to 5 m sec^{-1} is ascribed to the initial water film being laminar and then becoming turbulent. The author promises further study of these phenomena. Reviewer believes this work will be of interest to those concerned with the flow of disperse systems. J. W. Givens, USA

4628. Malinin, N. I., Investigation of the rheological properties of peat of low humidity content (in Russian), *Trudi Mosk. Torf. In-ta* no. 6, 61–83, 1957; *Ref. Zh. Mekh.* no. 2, 1959, Rev. 1825.

This paper is an experimental study of the deformation properties of peat of low humidity content. The procedure adopted in the experimental work is described. The study of the rheological properties followed the method of obtaining full rheological graphs, that is a series of curves in coordinates of shear γ – time t. In order to investigate the elastic-plastic properties of the peat the following apparatus was used: a device based on the observation of shear in a test sample between two parallel surfaces, a compression plastometer, a conical plastometer and a rotating viscosimeter. The difference in the behavior of peat in a state of plastic and semi-solid consistency during deformation was established. At stresses not exceeding the static limiting stress for shear θ_s, a peat of plastic consistency shows signs of momentary elasticity, elasticafter effect and slow flow; with stresses greater than θ_s the speed of flow is of the order of four times greater than with stresses less than θ_s. When the stresses are greater than θ_s the original network structure of the turf breaks down and the deformation comes to an end with an avalanche-like destruction at high velocities. During this process no disruption of continuity was observed. In turfs of semi-solid and solid consistencies there is no preliminary structural destruction, and the avalanche-like break-up is accompanied by disruption of continuity. The flow of peat of this nature is insignificant. The rheological properties of the peat are recorded with the aid of ten deformation characteristics which are not dependent on the stresses. A short review of the literature on the subject is given. Expression [2] in the paper

$$\frac{l^{2\mu} - l_0^{2\mu}}{l^{2\mu}} = \frac{P}{S_0}$$

contains an error: in the denominator on the right hand side, modulus E has been omitted. Here l_0 and l are the original and terminal lengths, P is the applied force, S_0 is the initial area of the section, μ is Poisson's coefficient.

V. S. Namestnikov

Courtesy Referativnyi Zhurnal, USSR

4629. Gent, A. N., Theory of the parallel plate viscometer *Brit. J. Appl. Phys.* **11**, 2, 85–87, Feb. 1960.

The material that is measured in such a viscometer is placed between two circular parallel plates and is deformed by applying a force to one of the plates. Previous theoretical treatments were based on the condition that the plate separation is small compared to the radius of the test piece. The author derived a theoretical equation for the compressive force, as function of rate of plate approach and test sample viscosity, that is valid for any plate separation. Use of a large plate separation or large test piece has the advantage that relatively small forces can be applied even when measuring the viscosity of highly viscous materials and also that the plate separation and the rate of change in plate separation can be measured more accurately. The author presents experimental data for a coal-tar pitch of Newtonian behavior, which are in excellent agreement with the theoretical equation and yield a viscosity of 1.96×10^8 poises, which checks within about 2% the viscosity measured for the same material by a Couette method.

Ruth N. Weltmann, USA

4630. Govier, G. W., Interpretation of rheological data for engineering use, *Engng. J., Montreal* **43**, 3, 79–84, Mar. 1960.

Increasing applications of the flow of complex mixtures such as solid-liquid suspensions, high pour-point crude oil and other non-

Newtonian materials require of the engineer some appreciation of the elements of rheology and the interpretation of laboratory measurements of consistency.

The basic rheological classifications are defined and reviewed. The versatile rotational viscometer is described and its calibration and use for the testing of non-Newtonians is outlined. A method of data interpretation for engineering use is presented. The method permits a ready visualization and assessment of the extent and kind of non-Newtonian behavior over a wide range of shear rate. From author's summary

Hydraulics

(See also Revs. 4402, 4656, 4697, 4703, 4741, 4753, 4767, 4837, 4925, 4938)

Book—4631. Ginocchio, R., Water-power engineering [Amenagements hydroelectriques], Paris, Eyrolles, 1959, 480 pp. 3500 F. (Paperbound)

This abbreviated treatise about water-power engineering is of interest to the specialist mainly for the many examples of French projects and for the extensive bibliography (220 entries). The chapter headings are as follows:

I. History of hydroelectric development in France and existing and potential developments.
II. Topography, hydrology, and sediment transport.
III. Definitions and operating principles.
IV. Discussion of low-head, medium-head and high-head developments with examples.
V. Generalities about dams.
VI. Fixed dams.
VII. Movable dams.
VIII. Auxiliary works (spillways, sluices, fish ladders)
IX. Inlet works to eliminate solids.
X. Diversion works to and from the powerhouse.
XI. Pressure conduits.
XII. Surge tanks.
XIII. Structures for controlling waves in canals and for groundwater level control.
XIV. Hydraulic turbines.
XV. Pumps.
XVI. Powerhouse equipment.
Appendix I. Model studies.
Appendix II. Economic comparison of hydro- and thermal power generation. M. R. Carstens, USA

4632. Kalitsun, V. I., Formulas for the Chézy coefficient in the light of experimental data (in Russian), *Gidrotekh. Stroit.* **28**, 1, 51–53, Jan. 1959.

Author uses 14 series of 116 reliable measurements for comparison of several most known hydraulic formulas for the friction resistance in open channels and pipes. A formula by A. D. Al'tshul' is selected for comparison. The Chézy factor $C = 20 \log (R/e)$, with hydraulic radius R and linear roughness e, suitable for the region of rough beds, shows the closest agreement with measurement data, even closer than Pavloskii and Agroskin formulas, which are standard in Russian. Another, more complex formula by Al'tshul' was applied for the transition region, also with reasonable success. S. Kolupaila, USA

4633. Oki, I., Some considerations on the characteristics of disc valves as disclosed by our experiments (Experimental research on disc valves, 6th report), *Bull. JSME* **2**, 8, 651–656, Nov. 1959.

Author made an overall study of his experimental researches on disk valves which have been reported since the year 1921. Many factors have been thereby brought to light as to the characteristics of disk valves with flat- or conical-seat, through which water was discharged in valve chambers of vertical cylinder type or angle-valve type, or discharged freely into the air.

From author's summary

4634. Dumitrescu, D., Ionescu, V., and Yanku, K., Theoretical and experimental investigation of flow in spillways (in Russian), *Rev. Mecan. Appl.* **4**, 2, 249–278, 1959.

Paper deals with the problem of ideal, two-dimensional open channel flow. Very limited survey of past work points out research by Villat who reduces solution to an integration for which the shape of the free surface must be postulated. Result yields solid boundaries, but is difficult to obtain. Infinite strip conformal mapping by John and by Lewy assumes knowledge of surface slope. Poncin, and also Haimovici, uses auxiliary mapping plane and formulates boundary-value problem which cannot be solved exactly and also requires information on surface shape.

Authors consider that problem is unsolved for practical purposes and propose solution based on finite difference formulas, derived in earlier paper. Sharp and broad-crested spillways are taken as examples. Treatment is elementary, with usual assumptions concerning upstream and downstream limiting conditions. Network solutions for stream function and corresponding flow nets are given for five different flow cases, four of which are apparently verified by tests. For these, a conventional laboratory flume with standard instrumentation is used, length and time scales being adjusted to ensure Froude similarity. No mention is made of magnitude of experimental error, nor is there any numerical comparison of theoretical and test results. Quality of agreement is merely illustrated by proximity of plots.

Authors claim that their method is simple since it can be applied by mathematical technicians, and yet sufficiently realistic, in spite of ignoring viscous effects. Reviewer believes this to be acceptable only for a limited number of simple subcritical flow cases. As evidenced by one of the worked examples, for supercritical upstream flow the agreement is far from good.

An irritating feature is the use of Bernoulli terminology where actually specific energy is involved.

T. Ranov, USA

4635. Tiber, Kh. A., An investigation of the discharge capacity of a weir with a wide sill (in Russian), *Trudī Tallinsk. Politekhn. In-ta* **A**, 110, 36 pp., 1957; *Ref. Zh. Mekh.* no. 8, 1958, Rev. 8779.

As a result of experiments made by the author, D. I. Kumin, A. R. Berezinsky, and others, the following methods are recommended for determining the flow coefficient of a weir with a wide sill, $m = f(H)$. For a weir with a rounded (radius r) horizontal entering edge, without lateral constriction, $m = \eta_s m_n$, where m_n is the discharge coefficient of the weir with a rectangular entering edge, determined by the analytical formula of M. D. Chertoasov which, as the author notes, gives satisfactory coincidence with the formulas of Bereizinsky and Kumin; η_s is coefficient of curvature determined by the author's formula:

$$\eta_s = 1 + \frac{p/H}{1 + p/H}\sqrt{\frac{0.15\, r_1/H}{1 + 2.4\, r_1/H}}$$

For a weir with zero height of sill ($p = 0$) and rectangular, vertical entering edges, $m = km_n$, where

$$k = 1 + 0.1\,(1 - \beta) - (0.06 + 0.1\,\beta)\sqrt{\frac{H/b}{1 + H/b}}$$

$\beta = b/B$; b space of the notch. For a weir with zero height of sill and rounded, vertical entering edges, $m = \eta_\beta m_n$, where

$$\eta_\beta = 1 + (0.3 - 0.27\,\beta)\left[1 - \sqrt{\frac{1 + 5\, r_2/b}{1 + 30\, r_2/b}}\right]$$

For a weir with rounded entering edges, with vertical and lateral constriction, $m = \eta m_n$.

For η, the lesser of the two values is taken, determined by the formulas:

$$\eta = \eta_s + \frac{1}{1 + p/H}(\eta_\beta - 1)$$

$$\eta = \eta_\beta + \beta(\eta_s - 1)$$

Tables of experimental data are not included in the paper.

A. R. Berezinskii
Courtesy Referativnyi Zhurnal, USSR

4636. Krasnov, V. Ya., Drainage of hydraulically filled earth dams built in river channels (in Russian), *Gidrotekh. Stroit.* **27**, 10, 33–36, Oct. 1958.

Author states that in building hydraulically filled earth dams in river channels, according to procedure "A," the toe drainage prism is usually formed by the cofferdam which is built by dumping stones in the river current before the beginning of the construction of the earth dam itself. At the upstream side of the prism a filter material is placed by dumping it behind cofferdams into the pool after they are completed. In some recent hydro-developments, including Kuibyshev, the construction was made by scheme "B," i.e. the drainage toe prism was built later and separately from cofferdams. In this case the cofferdams are not necessarily located in the downstream part of the dam and they are entirely covered by hydraulic fill in the process of construction. The drainage system is built on the fill and on a level higher than the river bed. The phreatic line is lowered less in scheme "B" as compared with "A." The reason for using "B"-type procedure on some jobs was the lack of cobblestone of good quality in needed quantity; on others, the necessity to develop dam profile downstream of cofferdams. Besides necessity to use it in some situations, scheme "B" offers an economy in selected materials for drainage facilities, which in turn lowers the construction cost. The more important advantage is the shorter time of construction and the possibility to begin the placing of hydraulic fill earlier, due to the fact that there is no need to place filters behind cofferdams as is the case in scheme "A."

The editor of the Journal comments on the author's comparison of both schemes and points out the necessity to prevent the piping of hydraulic fill into the cofferdams remaining in the dam body in scheme "B," which requires putting grading material between the fill and cofferdams, similar to a filter, which reduces in part the advantages of scheme "B." The reviewer may comment that the procedure "A" was used in all three upper Volga River hydroelectric developments. The middle Volga River Kuibyshev plant, where procedure "B" was used, has almost 2 million kilowatts of final installed capacity, which indicates the magnitude of the construction. The reviewer believes that both schemes have their own merits and both must be considered in analyzing technical advantages and in estimating the cost of each alternative. The most interesting fact, in general, is that while in the States the hydraulically filled dams are almost eliminated from construction practice, in USSR they are almost exclusively and successfully used. Soviet engineers at the 6th Congress on Large Dams, held in 1958 in New York, expressed their surprise in this respect, and asked us our reasons.

B. S. Browzin, USA

4637. Seleznev, V. M., An investigation of the kinematics of a flow in the region of expansion behind a half dam (in Russian), *Trudi Leningrad In-ta Inzh. Vodn. Transp.* no. 24, 42–52, 1957; *Ref. Zh. Mekh.* no. 8, 1958, Rev. 8769.

An experimental investigation of the flow structure behind a half-(partial) dam. Using different ratios of dam-height to flow-depth, the boundary of the deadwater (eddy) region behind the construction is determined. The measured boundaries of the deadwater region are compared with those calculated by the theory of J. M. Konovalov ["Turbulent currents," *Trudi Akad. Recbn. Transp.* no. 1, 1952]. It is shown that, for coincidence of the measured with the calculated velocity fields, the introduction of an empirical correction term is required, by approximately doubling the coefficient a entering into Konovalov's equations. The divergence between the calculated length of the deadwater region and the experimentally observed length increases with decreasing height of the dam, and attains 35% for a dam height of 0.2 of the flow depth. Qualitative study of the singularities of formation of channel beds indicates an intimate relationship between bed formation and flow structure; in particular, the connection between the appearance of breakaway points in the boundary layer and the formation of sandbars is confirmed.

E. M. Minskii
Courtesy Referativnyi Zhurnal, USSR

4638. Muss, D. L., Friction losses in lines with service connections, *Proc. Amer. Soc. Civ. Engrs.* **86**, HY 4 (*J. Hydr. Div.*), 35–47, Apr. 1960.

4639. Goodrich, R. D., Tolkmitt's backwater and dropdown curve tables, *Proc. Amer. Soc. Civ. Engrs.* **86**, Hy 5 (*J. Hydr. Div.*), 1–6, May 1960.

Tables and formulas are presented for the computation of backwater and dropdown curves for channels of parabolic section. These are followed by cautions as to the selection of the coefficients C and n when used in connection with the computation of water-surface curves.

From author's summary

4640. McFarlane, H. M., and Gotlieb, C. C., Backwater computations for the St. Lawrence power project, Part 1, Hydraulic engineering aspects of computation; Part 2, Backwater calculations on the Ferranti computer, *Engng. J., Montreal* **43**, 2, 55–66, Feb. 1960.

Part A outlines the "standard step" method used in analyzing some 99 backwater curves required for 40 miles of complex river channel divided by islands between the Cornwall power dam and Chimney Point. A modified Chezy-Manning formula was used for friction evaluation and crude allowances made for expansion and bend losses. Sufficient gage records could not be obtained in time to evaluate 'n,' so calculation proceeded using a wide range of channel roughnesses. (This range of roughnesses together with the required flow and elevation combinations gave the 99 cases). While computations were being run, results from an established gaging program were being processed to give existing 'n.' From these, more reliable estimates for final (increased level) channel roughnesses were made.

Part B presents the equations in general form and outlines the iterative procedure to evaluate depths over each section. The island network problem is treated using flow diversion parameters. If level changes around loops do not agree corrections to the flow diversion parameters are computed and iteration continues until the depth error is sufficiently small. Some trouble was experienced with oscillatory solution.

Computer flow diagrams appropriate for the Ferranti *Feorut* computer used are discussed together with problems of scaling and error checking.

Reviewer believes it to be an excellent paper, setting down hydraulic requirements clearly and demonstrating the method and value of digital computer solution.

R. Culver, S. Australia

4641. Izzard, C. F., and Bradley, J. N., Field verification of model tests on flow through highway bridges and culverts, Proceedings of the Seventh Hydraulics Conference, Iowa Institute of Hydraulic Research, June 16–18, 1958; Iowa City, Iowa, State Univ. of Iowa, 1959, 225–243.

Book—4642. Levi, I. I., The dynamics of channel flows (in Russian), Moscow-Leningrad, Gosenergoizdat, 1957, 252 pp.; *Ref. Zh. Mekh.* no. 8, 1958, Rev. 8777.

The first part of the book deals with problems of the hydraulics of river channels. It reviews the results of the researches of A. N. Rakhmonov concerning unsteady states in river flows, and the theory of S. A. Khristianovich ["Some fresh problems of the mechanics of a continuous medium," Moscow, Leningrad, 1938]. Very brief reference is made to the results of the conventional theories (of the 1930's) concerning the velocity profiles and resistance values of plane, turbulent flows. Information is given on the mechanism of the curvature of river channel flows, as conceived by N. E. Zhukovsky, as well as the results of some recent researches on the calculation of the circulations in the cross section of greatest curvature. The calculation of a current chart according to the method of N. M. Beriadskiy is presented and supplemented by the results of the present author's researches on the projecting of current charts in the presence of eddy regions in steady-state flows.

The sections of the book dealing with the dynamics of channel flows begin with a series of data from the sphere of engineering hydrology and hydrography (state and run-off of deposits, erosion flows, hydromorphology). Further, a condensed account is given of the general principles of the mechanism of the steady motion of deposits, and the results of the numerous experimental and theoretical researches of N. E. Zhukovsky, M. A. Velikanov, the present author, and others. The problem of the flow velocities in the steady-state movement of river-bed deposits is examined outside the scope of the section dealing with the mechanism and analysis of deposit movements, following an exposition of the theory of suspension of deposits. In the section dealing with the problem of sediments in suspension, the theories of V. M. Makkaveyev, M. A. Velikanov and G. N. Barenblatt are presented; the comparative analysis of these theories concludes with the statement that this problem has not yet found a complete solution. The section on the hydraulic dimensions of sediments presents some hydromechanical problems concerning the flow resistance of bodies in an infinitely extending flow (Stokes, Prandtl). In the proof of the analytical formulas presented for the calculation of hydraulic dimensions, no use has been made of the experimental results of B. V. Arkhangelsky (1935). Considerable space is given to a description of the methods of calculating river-bed distortion, developed by the present author.

The last part of the book is devoted to methods of calculating the distortions in the reservoirs of hydraulic power plants (choking and silting of upper reservoirs, scouring of lower reservoirs, accompanied by lowering of the levels in the latter). This section also discusses methods of calculating deformation of the channel bed in deviation sections and in the presence of constriction by dams. The main sections of the book are illustrated by examples.

V. N. Goncharov

Courtesy Referativnyi Zhurnal, USSR

4643. Binnie, A. M., Instability in a slightly inclined water channel, *J. Fluid Mech.* **5**, 4, 561–570, May 1959.

Author studies the stability of the motion of a continuous thin water film which flows in laminar regime along a channel inclined downward at an angle θ. He gives the theoretical expression of the amplification factor A for long waves of infinitely small amplitude.

For channels inclined at angle $\theta = 90^\circ$, theory and experience show that $A = 0$ and that flow is unstable even for very small values of Reynolds number R, defined as the discharge for unity width divided by kinematic viscosity. For $\theta < 90^\circ$ there is a value R_1 of Reynolds number below which the flow is stable. The curves representing A as a function of R become flatter as θ decreases.

If reference to superficial velocity, measured in the central zone of the channel, is made, theoretical results are in good agreement with data obtained by author through an ingenious experimental technique.

Finally the onset and development of turbulence is investigated. The onset takes place first in a random manner leading to the production of intermittent bores moving more slowly than the laminar stream. The process of transition was random both in time and place. Influence of the change of slope was obscured by the capricious nature of the disturbances. Transition was found at $R = 2500$; this value is a mean in which the irregularities were short compared with the time of measurement. The stream was continuously occupied by turbulence when R ranged from 4000 to 4500.

It does not appear that author has considered the influence of temperature in estimating the value of Reynolds number.

A. Russo Spena, Italy

4644. Al'tshul', A. D., Models of gradually varied open streams with unerodable beds (in Russian), *Gidrotekh. Stroit.* **28**, 2, 49–51, Feb. 1959.

Author disagrees with interpretation of similarity criterion obtained by Pikalov, stating that constancy of ratio of Froude number to channel slope implies simultaneous Froude and Reynolds similarity. Reviewer believes that confusion is due to introduction at this stage of the (not dimensionless) Chézy coefficient. Correct conclusion is, of course, that requirement of constant Froude number, when used in (constant) Reynolds number, leads to need for constant slope, regardless of nature of wall shearing stress. In other words, both Froude numbers and slopes must be equal for this type of similarity between model and prototype flows, not merely their ratio.

Author discusses resulting requirement of equal Chézy coefficients and conclusions concerning required model roughness. Well-known equations by Pavlov, Manning and Bazin give model roughnesses valid only for square resistance law, i.e. for large models, steep slopes and very rough surfaces. For special types of model roughness, small model scale, and at low Reynolds numbers, dependence of Chézy coefficient upon the latter (and, therefore, upon the slope) is considerable and occasionally applies for prototypes. Application of complete Ganguillet-Kutter formula for models does not satisfactorily solve this problem, as pointed out already by Rehbock. Formula for Chézy coefficient, based on semiempirical turbulent theory, including effect of slope (proposed earlier by author) is used to obtain model roughness, based on equality of Chézy coefficients and slopes. Final result is $\varepsilon_M = (\varepsilon_N)L) + (0.004)/(R_N \cdot i)^{1/2}[(1/L) - L^{1/4}]$, where ε_M and ε_N are model and prototype roughnesses, respectively, $L = R_N/R_M$ is the ratio of prototype and model hydraulic radii (scale), and i is the common slope. Worked example demonstrates need for careful selection of laboratory model scale to ensure turbulent flow, feasible model roughness, and freedom from surface tension effects. In Eq. [2] $\sqrt{9}$ should be $\sqrt{g}$.

T. Ranov, USA

4645. Ananyan, A. K., An approximate solution of the problem of transverse circulation in a channel of triangular cross-section at a bend (in Armenian), *Izv. Akad. Nauk ArmSSR. Ser. Tekhn. Nauk* **10**, 3, 3–20, 1957; *Ref. Zh. Mekh.* no. 8, 1958, Rev. 8748.

Introducing the hypothesis of a linear relationship between the supplementary stress components and the mean rates of deformation, the hydrodynamic equations in the projections of the divergence of the stress tensor are averaged and written for the steady flow of a viscous liquid in cylindrical coordinates. The Euler function, entering into the composition of the expressions thus obtained for equations of Lamb's form, is excluded from further consideration. The fundamental equations receive the addition of the equation of continuity, from which, on the assumptions

already made by the author in another paper [*Dokladi Akad. Nauk*, USSR (N.S.), **109**, 2, 275–278, 1956], the distribution function of the transverse circulation $F(R, z)$ is determined. The problem is solved by the method of small parameters. The flow is regarded as a turbulent nucleus in a laminar envelope adhering to the solid wall of the channel, at which boundary conditions for the function $F(R, z)$ are applied. For the case when the cross section of the channel is a right-angled, isosceles triangle, the problem is solved by the Galerkin method. Numerical values of the transverse velocities are given for a particular example.

V. V. Musatov

Courtesy Referativnyi Zhurnal, USSR

4646. Kalinin, G. P., and Milyukov, P. I., Analysis of the unsteady flow of water in an open channel (in Russian), *Meteorol. i Gidrologiya* no. 10, 10–18, 1957; *Ref. Zh. Mekh.* no. 8, 1958, Rev. 8757.

An approximate method is demonstrated for calculating the flow volume in open channels in the case of unsteady motion. The flow volume through any given cross section is, in that case, a function of the depth and the gradient; in the presence of an initially steady flow, let both these functions vary simultaneously in the particular cross section in such manner that the flow volume Q remains constant; then, in this cross section,

$$\frac{\partial Q}{\partial h}dh + \frac{\partial Q}{\partial i}di = 0$$

(h and i = depth and gradient in the case of a steady flow). Assuming the longitudinal profile of the surface of the flow to be rectilinear, it is possible to show that $dh = -l\,di$, where l is the extension of the particular length of the profile (with changing depth and gradient) from the cross section under consideration to the intersection with the surface line, for the case of steady motion. Considering further that

$$\frac{\partial Q}{\partial i} = \frac{k}{2\sqrt{i}} = \frac{Q}{2i}$$

(where k is the modulus of the flow volume), then

$$l = Q\left(2i\frac{\partial Q}{\partial h}\right)^{-1}$$

The quantity l is, strictly speaking, a function of the depth. The authors of the present paper are of the opinion, however, that it is practically permissible, as a result of their investigations on the problem in question, to assign to this quantity (for an actual cross section in an actual flow) an identical value for all degrees of filling of the channel. Accepting this proposition, it is possible to divide the channel by a series of sections into partial lengths of each $2l$, where the value of l is determined for each length. A level mark z in the middle of each such length will uniquivocally determine the volume of flow through the end cross section; and, in the case of a prismatic or rectangular channel, also the volume of the contained water in that length. The relationships $W = f(z)$ established for these lengths enable, in conjunction with the equation of continuity, calculation of the case of unsteady motion; apparently more simply than is possible, for instance, by the method of instantaneous states. This is the essence of the suggested method. The assumptions used in its development appear at first sight to be very rough. The paper gives, however, a comparison of a calculation made by this method with the results of hydrographic measurements of unsteady motion on an actual river; in reality, the approximation is found to be extremely close, and much better than when, for the same river, a detailed analysis was made by the methods of characteristics and instantaneous states. This circumstance is worthy of attention, in reference to the suggested method, although further verification of the assumptions used therein would appear to be essential; this is in agreement with the statements of the present authors, who themselves consider it will be necessary "more nearly to define the conditions under which the suggested method may be expected to furnish acceptable results."

V. A. Arkhangel'skii

Courtesy Referativnyi Zhurnal, USSR

4647. Nazarov, M. I., Scouring and permissible flow velocities in pitched channels (in Russian), *Trudi In-ta Vodn. Kh-va i Energ., Akad. Nauk KirSSR* no. 4 (7), 76–83, 1957; *Ref. Zh. Mekh.* no. 8, 1958, Rev. 8764.

The results are presented of experimental investigations on the scouring velocities in (stone) pitched channels, made by the author under full-scale (natural) conditions. In the conditions obtaining, of very low values of h/Δ, where Δ is the influence of the surface protuberances, it is recommended to determine the velocity profile by an exponential relationship, in which the exponent, differing from the usual formulas (Manning, Pavlovsky, and others) has a value of 1/3; the value of h/Δ varies between 0.4 and 8.0. An expression is also suggested for the value of Δ depending on the mean height of the roughness protuberances, Δ_m. From observed data, the following expression is derived

$$v_p = 3.22\left(\frac{R}{\Delta_m}\right)^{1/6}\sqrt{d}\left[\frac{m}{\text{Sec}}\right]$$

(d in meters), which is correct for the conditions of a cobbled causeway.

I. I. Levi

Courtesy Referativnyi Zhurnal, USSR

4648. Trofimov, G. I., The construction of a rational contour of a flow boundary at branching points (in Russian), *Trudi Leningrad In-ta Inzh. Vodn. Transp.* no. 24, 53–61, 1957; *Ref. Zh. Mekh.* no. 8, 1958, Rev. 8768.

In designing a variety of hydraulic engineering structures and installations, the problem arises of determining a rational form of contour for the flow boundary at branching points (bifurcations),—i.e. a boundary that the flow can follow in a fair curve, without constriction or breakaway, which is equivalent to a smooth, continuous increase in the velocity of the flow along the boundary. This gives rise to the following hydromechanical problem: a two-dimensional flow of a perfect and incompressible fluid, having a finite width at infinity, bifurcates; find the form of the boundaries of the said flow for a given distribution of the velocity along the boundary. One method of solving this problem is as follows: the region of change of the hodograph of the velocity of the flow in question is determined in such manner that its boundary coincides with the required change of velocity along the flow boundaries, and that the transformation function on the upper semiplane is known, the particular region of the hodograph and the region of change of the complex potential, in this case a band with a cut, are conformally transformed on the upper semiplane of a particular, auxiliary complex variable. The solution is then obtained in terms of a parameter, in closed form. The simplicity and efficacy of the solution depend on the suitable selection of the particular hodograph of the velocity. V. M. Makkaveyev [*Trudi 2-go Vses. Matem. S'yezda* **2**, 1936] has already examined the case in which the region of the velocity hodograph is selected as a circular sector with the coordinate origin on the circumference. In the present paper, the solution is stated for the case where the region of the velocity hodograph selected is bounded by two circular arcs with the coordinate origin on one of them. The solution in its ultimate form is represented in elementary functions. Differing from the case investigated by Makkaveyev, the present solution enables consideration of an axisymmetric flow. A method is stated for determining the arbitrary parameters of the solution by particular velocities and flow volumes.

G. N. Pyikkteev

Courtesy Referativnyi Zhurnal, USSR

4649. Yakovlev, N. A., The problem of the analysis of a transient overflow (in Russian), *Nauchno-tekhn. Inform. Byul. Leningrad Politekhn. In-ta* no. 8, 3–18, 1957; *Ref. Zh. Mekh.* no. 8, 1958, Rev. 8783.

Considerations are presented on the calculation of the apertures in a horizontal overflow at the end of a transient flow (an overflow). The author has assumed that, in the initial cross section of the aperture, the vertical distribution of the average velocities follows an exponential law. Substituting the expression of the mean velocity in the known equation of the trajectory of a free-falling particle, he obtains, after suitable transformations, an expression for the unit flow through such an aperture. The experimental investigations were made on a model of a transient flow of a width of 60 cm, a height of fall of 30.75 cm, slope of the bottom of the flow channel of 0.25, and a horizontal flow section of 30 cm in length. The experiments were made with a single aperture (width 60 cm), as well as with a number of apertures, separated from each other by longitudinal bars of a width of 2, 3, 4 and 6 cm. From the experimental results, values are obtained for the parameters of the analytical expression for the flow through an aperture.

V. V. Fandeev

Courtesy Referativnyi Zhurnal, USSR

4650. Voynich, T. G., The influence of a hydraulic discontinuity at the bottom on the extinction of energy (in Russian), *Izv. Tbilissk. Nauk-i. In-ta Sooruzb. i Gidroenerg.* **9**, 29–43, 1955; *Ref. Zh. Mekh.* no. 8, 1958, Rev. 8789.

From the curve of a submerged discontinuity in an outflow under a screen (in the conditions of the two-dimensional problem), and applying the Bernoulli equation, a differential equation is derived for the motion of the primary flow, bounded above by the curve of zero velocities in the eddy. An attempt is made to allow for macroscopic pulsations in the flow, and the disturbance of the hydrostatic law of pressure distribution. The term expressing the energy losses is represented as the sum of the losses due to friction and to motion of the flow, on the condition that addition or abstraction of fluid takes place at an angle of 90° to the primary flow. The calculations are made under the usual assumptions of zero frictional loss, pressure distribution according to a hydrostatic law, and parabolic profiles of the curves of the free surface and the line of zero velocity. From the resulting equation, and the equation of quantity of motion for the discontinuity, an expression is derived for the velocity correction in the cross section immediately following the eddy. The author recommends this formula for practical calculations. The calculated results presented in the paper agree with the experimental data. V. B. Dul'nev

Courtesy Referativnyi Zhurnal, USSR

4651. Schmid, J., Motion picture investigation of one bubble cavitation (in German), *Acustica* **9**, 4, 321–326, 1959.

By using the inertia forces which are set up by the sudden deceleration of a fast-moving liquid column, spherical cavitation bubbles of over 1-cm diameter can be reproduced in water. Cinematograph studies are made of the formation, collapse, and rebound of the bubbles, as well as of the very strong shock waves set up by the implosion. Similar experiments give rise to luminescence in glycerine. From author's summary

4652. Tulin, M. P., Supercavitating flow past slender delta wings, *J. Ship Res.* **3**, 3, 17–22, Dec. 1959.

The supercavitating flow past slender delta wings is studied. Theory is developed for a conical flow involving cavities which spring from the leading edges of the delta and cover a part of the top of the wing; the center part of the wing top is assumed to be wetted by a kind of re-entrant jet flow. Results are obtained for the two separate asymptotic cases in which the cavitation number is either very small or very large. The widths of the cavities on the wing upper surface increase with decreasing σ and the lift decreases. It is shown that the upper surface never becomes completely enveloped in a cavity even for $\sigma = 0$. Finally, the lift of a fully cavitated wing ($\sigma = 0$) is estimated to be approximately 4/10 of its fully wetted lift.

From author's summary by P. Franke, Germany

Book—4653. Muszkalay, L., and Starosolszky, O., Water measurement manual [Vizhozammeresi Zsebkonyv], Budapest, Muszaki Konyvkiado, 1959, 268 pp.

This manual contains a large amount of practical information about the methods of water discharge measurement. Part I is devoted to individual measurements. The accuracy of the methods discussed and their practical problems are treated. The watercourses are grouped by their magnitude and their preferable method of measurement is discussed. Part II deals with continuous-flow measurements, such as the different weirs, flumes, orifices, meter gates, venturi tubes, by-pass measurements, recording equipments, etc. Part III outlines practical applications of the described methods in rivers, canals, pumping stations, etc.

The book contains a remarkably large amount of information collected from the literature and from field experience, on a critical basis. There are many useful tables and graphs. There is a summary, a list of tables and an index, as well as English titles on the figures. A. L. Simon, USA

Incompressible Flow

(See also Revs. 4405, 4629, 4634, 4646, 4652, 4694, 4695, 4697, 4737, 4753, 4755, 4758, 4770, 4772, 4819, 4833, 4841, 4860, 4913, 4941, 4946, 4956, 4958, 4970)

4654. Brenner, H., Pressure drop due to viscous flow through cylinders, *J. Fluid Mech.* **6**, 4, 542–546, Nov. 1959.

In a novel and useful paper, author shows how the pressure drop in slow steady flow through a straight circular pipe may be calculated from the given boundary conditions on the velocity. Application is made to the case of Poiseuille flow as disturbed by a point force acting upstream at a given point on the axis; from this calculation the additional pressure drop due to a small spherical particle situated on the axis is then deduced, the formula being valid for small values of the ratio of radius of particle to radius of pipe. J. T. Stuart, England

4655. Serrin, J., On the stability of viscous fluid motions (in English), *Arch. Rational Mech. Anal.* **3**, 1, 1–13, Mar. 1959.

Author applies the Reynolds-Orr equation for the rate of change of the energy of the perturbations of the motion of a viscous incompressible fluid confined between fixed rigid boundaries at finite distance for obtaining sufficient conditions for the stability of the basic motion. By use of some inequalities two "universal stability criteria" affirming the exponential decrease of the perturbation energy are obtained, and a variational technique is proposed for obtaining a "best possible" criterion of this type.

As an example the stability of the Couette flow is treated by the assumption of Taylor-Gortler vorticies as perturbations, and considerations of the energy of a single vortex. The results, even if inferior to those obtained by the method of small perturbations, are nevertheless interesting as an example of the energy method applied to problems of hydrodynamics stability.

L. S. Rintel, Israel

4656. Gurevich, M. I., On the instability of certain jet flows with free surfaces, *Soviet Phys.-Doklady* **4**, 1, 54–56, Aug. 1959. (Translation of *Dokladi Akad. Nauk SSSR (N.S.)* **124**, 5, 998–1000, Jan./Feb. 1959 by Amer. Inst. Phys., Inc., New York, N. Y.)

Potential flow of uniform liquid with free surface in absence of gravity, with and without surface tension, vacuum above, is considered to see if it is unstable. Particular interest lies in the conclusion that disturbances may grow exponentially even though the velocity potential does not increase but is neutrally stable.

R. S. Scorer, England

4657. Bankoff, S. G., On Taylor instability of plane surfaces, *Physics of Fluids* **2,** 5, p. 576 (Research Notes), Sept./Oct. 1959.

4658. Gol'dshtik, M. A., Screw flow of an incompressible fluid in a circular tube (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 12, 24–31, Dec. 1958.

Backed by some experimental evidence, author assumes the flow which is produced by a whirling apparatus placed into a circular tube to be axially symmetric and to be essentially governed by equilibrium between pressure and inertia forces. Viscosity is neglected. He introduces a stream function for the velocity components within a meridian section, and establishes that the quantities $p/\rho + v^2/2$ and r are both functions of this stream function, say, $P(\psi)$ and $\phi(\psi)$ respectively. By a suitable choice of these latter functions, selected as reasonable approximations to experiences with certain types of whirling devices, the partial differential equation for the stream function becomes linear and can thus be solved by classical analytical methods. The solutions are somewhat involved and not easily handled, however the results compare surprisingly well with experiments, which seems to support the soundness of the general approach. In particular it appears that a back flow near the axis, known from observations, is correctly predicted by the theory.

A. Von Baranoff, Germany

4659. Breslin, J. P., and Tsakonas, S., The blade frequency velocity field near an operating marine propeller due to loading and thickness effects, Proc. 6th Midwest. Conf. Fluid Mech., Austin, Texas, Sept. 1959; Austin, Texas, Univ. Press, 149–168.

Authors present an analysis of the velocity variations in the neighborhood of a propellor operating in open-water conditions with uniform inflow. An incompressible ideal fluid is assumed. The velocity field is derived from the flow induced by vortex-lines and, for blade thickness effects, from the flow induced by distributed combinations of sources and sinks.

The ultimate objective is the effect of time-varying velocities on nearby bodies. Hence "resonant" Fourier components of the velocities are determined. Authors conclude that the major velocity variations arise from the blade thickness effect and from the bound vortex which lies along the middle-chord line.

E. J. McBride, USA

4660. Huhnt, D., Stable forms of flow and transition phenomena in a layer of water on a slightly inclined flat plate (in German), Dtsch. Versuchsanstalt Luftfahrt, Ber. 92, 62 pp., July 1959.

Transition of laminar flow to turbulence is studied in a detailed series of experiments. Several stable forms of flow are discerned. In addition to the classic uniform laminar flow there are two forms of laminar wave motion, one consisting of lateral wave fronts and the other lateral lines of surface "dimples." From a generalized analysis of the equations of motion the characteristics of the wave motion are defined and it is shown that regions in which these forms exist are bounded by relationships involving only the Reynolds and Weber numbers of the flow. Numerical forms of the relationships are obtained from the experimental data. There is only a small region in which the two-dimensional waves exist, but a very large region is found where the dimple waves are stable.

The mechanism by which the flow changes from laminar to turbulent is also observed. Clear photographs are presented to illustrate the growth of the dimple waves to spots of turbulence. These then grow rapidly to cover the flow field. Measurements indicate that the amplification of the infinitesimal disturbances occurs for Reynolds numbers greater than 970. The conversion is not influenced by the Weber number.

W. D. Baines, Canada

4661. Werle, H., Some observations on the vortices at the leading edge of a body in a water tunnel (in French), ONERA Pub. 70, 15–23, May/June 1959.

Taking advantage of the visualizations of the water flow obtained by an experimental technique previously described [Werlé, H., Aperçu sur les possibilités expérimentales du tunnel hydrodinamique à visualisation de l'O.N.E.R.A., ONERA, TN48, 1958], author analyzes the mechanism of the vortices separating at the leading edge of bodies in particular conditions.

Two-dimensional study determines the influence, on the essential features of the flow, of the parameters: incidence, angle of the leading edge, suction coefficient, distance between airfoil and wall.

Study is completed by some qualitative results of three-dimensional experiments, available for incompressible flow and at low velocity ($R \simeq 10^4$).

From author's summary by G. Noseda, Italy

4662. Kapur, J. N., On axially symmetric superposable flows, *Bull. Calcutta Math. Soc.* **51,** 1, 25–33, Mar. 1959.

Paper deals with the axially symmetric superposable flows [see AMR **11** (1958), Revs. 130; 1674] and some cases are shown where the conditions of integrability of the equations of motion are satisfied. Author shows a case in which the condition of the superposability for the nonviscous flows is not satisfied for viscous. Four theorems for two self-superposable flows are established and some nonsteady solutions for the decay of vorticity in axisymmetric case are studied and the solutions are expressed in terms of Bessel's functions of order unity. G. Sestini, Italy

4663. Rumiantsev, V. V., The stability of Maclaurin ellipsoids of a rotating fluid, *Appl. Math. Mech. (Prikl. Mat. Mekh.)* **23,** 3, 701–715, 1959. (Pergamon Press, Inc., 122 E. 55th St., New York 22, N. Y.)

Paper investigates the stability of a rotating oblate ellipsoid of fluid under the action of Newtonian gravitational forces. General equations for the variation of axes with time are formulated, geometrical stability criteria are obtained, and the simple problem of an ellipsoid initially in uniform rotation about its polar axis is investigated. L. Trilling, USA

4664. Al'tshul', A. D., Sveshnikov, I. P., and Laskov, Yu. M., Generalized relations for the hydraulic calculations for high and low pressure gas pipe conduits (in Russian), *Vodosnabzh. i San. Tekhn.* no. 4, 34–39, 1958; *Ref. Zh. Mekh.* no. 2, 1959, Rev. 1306.

Authors analyze defects of methods available in practice for making hydraulic calculations for pipe conduits. A comparison is made of the experimental data of a number of authors with the results of calculations made by Al'tshul's generalized formula for the coefficient of hydraulic resistance in pipes

$$\lambda = 0.1 \left(\frac{k_1}{d} + \frac{100}{R} \right)^{1/4}$$

where $R = vd/\nu$ is Reynolds number for the flow in the pipe, k_1 the reduced linear rougness, d the diameter of the pipe. It was shown that calculations according to the generalized formula agreed, with a degree of accuracy sufficient for practical purposes, with experiment over a wide range of changes in the R number and in the roughness k_1. The limiting forms of the formulas for pipe

conduits working at low and high pressures and the limits of application of these formulas were investigated.

V. D. Sokolov

Courtesy Referativnyi Zhurnal, USSR

4665. Bogyadin, M. N., Calculations for a ventilation network by the method of equivalent depression (in Russian), *Izv. Sibirsk. Otd. Akad. Nauk SSR* no. 3, 91–98, 1958; *Ref. Zh. Mekh.* no. 2, 1959, Rev. 1329.

An analytical method of calculation is worked out for computing the general consumption of air in its distribution throughout the separate sections of a ventilation network, when the resistances and depressions in the direction of the flow are known in these sections. The essence of the method is embodied in the fact that the sum total of the action of the depressions of the parallel branches, which differ in magnitude, is substituted by the equivalent action, in accordance with the general flow of air, of one depression, which is general for all the branches when there is a natural distribution of air in the connections. This enables simple formulas to be derived for rapid computations in the network. The results of the calculations made by the method agree satisfactorily with the results of calculations carried out by different methods.

V. D. Sokolov

Courtesy Referativnyi Zhurnal, USSR

4666. Yaborskii, I. A., The structure of the flow of a single jet in a system of plane jets (in Russian), *Izv. Sibirsk. Otd. Akad. Nauk SSR* no. 2, 62–74, 1958; *Ref. Zh. Mekh.* no. 2, 1959, Rev. 1350.

An analysis is carried out of the structure of a single jet and of a system of jets flowing from nozzles of rectangular section. The experimental data obtained by the author for the single jet are compared with Dyunin's theoretical solution. It was found that the geometrical similarity of velocities in the transverse section of the jet was only maintained in nozzles with round outlet section and in rectangular nozzles with ratios of their sides $A/b > 30$. A jet emerging from the nozzles in other shapes assumed the form of a round jet at a comparatively short distance from the section of the nozzle. Empirical relations are drawn up for the axis velocity, mean velocity, consumption and boundaries of the jets, to deal with a system of plane-parallel jets. The question is worked out regarding the ejecting properties of a system of jets. It is found that if

$$\zeta > \left(\frac{F_0}{F}\right)^2 - 1$$

where ζ represents the sum total of the resistance (friction, eddying, etc.) of the flow of the jet system, F_0 the total sectional area of the nozzles, F the area of the section of the mixing chamber, then there will be no suction of air into the chamber from the external medium.

V. D. Sokolov

Courtesy Referativnyi Zhurnal, USSR

4667. Moore, D. W., The rise of a gas bubble in a viscous liquid, *J. Fluid Mech.* **6,** 1, 113–130, July 1959.

A theoretical paper. The principal result is that when the Reynolds number R (based on diameter of bubble) is large (but subcritical) and when the Weber number W is small (less than 0.1), the bubble shape may be regarded as spherical and the drag coefficient is shown to be $32/R$. This result is in good agreement with the measurements of Haberman and Morton in the Reynolds number range 10 to 100.

Photographic evidence exists that bubble shape can depart considerably from the spherical. The theory is therefore extended to ellipsoidal bubbles, for which the drag coefficient is shown to increase with increasing oblateness. Finally, an inviscid model of the spherical cap bubble (umbrella shaped) involving separated flow is considered.

T. C. Tsu, USA

4668. Korotaev, Yu. P., Influence of a liquid on the motion of a gas along vertical tubes (in Russian), *Trudi Vses. Nauk-i. In-ta Prirodn. Gazov* no. 2(10), 48–68, 1958; *Ref. Zh. Mekh.* no. 2, 1959, Rev. 1632.

The motion of a gas and of a gas-saturated liquid is investigated theoretically and experimentally in order to determine the values of the coefficients of resistance to friction in the shafts of gas wells. The experimental investigation was carried out on a specially built apparatus at pressures less than 2 atm and on industrial gas and gas-petroleum wells.... It was established that when only a small quantity of liquid was involved the values of the coefficient of friction are smaller than in the motion of a pure gas. With increase in the amount of liquid the value of the overall coefficient of friction increases and becomes larger than for pure air. The maximum influence of the liquid is to be seen with low Reynolds numbers. In the theoretical solution of the problem of the isothermal joint motion of a gas with an admixture of a small quantity of liquid an equation is obtained whose solution is effected in the paper by the method of successive approximations. For the practical determination of site pressures an empirical formula is proposed; here the influence of the liquid is taken into consideration by means of the over-all coefficient of resistance to friction, determinable on the basis of experimental data.

N. S. Kondrat'ev

Courtesy Referativnyi Zhurnal, USSR

4669. Lutoshkin, G. S., Belen'kii, V. N., and Nikitina, N. I., Investigation of the motion of gas-liquid mixtures in the spaces beyond the pipe conduit system (in Russian), *Trudi Vses. Neft. Nauk-i. In-ta* no. 13, 30–37, 1958; *Ref. Zh. Mekh.* no. 2, 1959, Rev. 1633.

Results are furnished of experimental investigations carried out to study the loss of energy in the spaces beyond the pipe system in overcoming friction along the walls of the tubes and sleeves during the motion of gas-liquid mixtures and in the relative motion (slipping) of a gas. The experimental installation was equipped with double-row lifts consisting of pump-compressor tubes 4×2.5 inches and 4×2 inches. It is noted that every series of experiments was carried out with a constant discharge of oil into the lift and a variable expenditure of air (from a zero reading up to the corresponding full capacity of the compressor). The input of oil for each lift was chosen with a view to obtaining correspondence with the actual yield of the petroleum wells and to ensure that the velocities for the liquid selected for the accepted input of oil for these lifts (from 0.96 to 2.7 1/sec) were identical (from 0.268 to 0.75 m/sec). Losses of pressure due to friction as measured on the laboratory apparatus were somewhat higher in comparison with the magnitude of the inertial pressure which, because of the experimental conditions could not be separately determined. It is stated that according to A. A. Armand's data, the inertial pressure is never greater than 5% of the loss of pressure due to friction. Empirical formulas are derived for the calculations of the loss of pressure due to friction and for the determination of the mean specific gravity of the liquid and the air during the work of a double-row lift in the space beyond the pipe system; these are based on the results of analysis of the experimental material and a study of the corresponding graphical relations. Notwithstanding the fact that the tests were carried out with oil of a single constant viscosity (12 c poises) authors put forward the proposition that the viscosity of a liquid in a two-phase flow, because of its strong turbulence, should not exercise any appreciable influence on pressure losses due to friction. The boundary is established of the transition of the emulsified structure of the flow to the

beaded structure. The results of the falls of pressure on the connecting sleeves are set out in a table, whose contents are used to put forward practical recommendations. The claim is made that using the proposed formulas and the known data for the work of gusher lifts it is possible to carry out calculations for site pressures in wells working in a ring. G. E. Khudyakov

Courtesy Referativnyi Zhurnal, USSR

4670. Kudryashev, L. I., and Sychev, M. Ya., Adding precision to the hydraulic calculations for a pipe conduit working at high pressure in conditions of isothermal motion of the gases (in Russian), *Izv. Vyssh. Uchebn. Zavedenii, Energetika* no. 4, 76–80, 1958; *Ref. Zh. Mekh.* no. 2, 1959, Rev. 1308.

It is shown that when determining the hydraulic resistance in pipe conduits of great length it is impossible to disregard, as is done in the deduction of the widely applied Weymouth formula, the inertia term in the equation for impulses. Taking into account the inertia term in the impulse equation, authors derive a formula for the determination of the consumption of gas in the gas conduit

$$Q = QB \sqrt{\frac{2(1 - M_0^2 (p_0/p_1))}{1 + p_1/p_0}}$$

where QB is the input calculated by the Weymouth formula, p_0 and p_1 are the pressures at the beginning and the end of the gas conduit respectively, M is the Mach number. Inputs calculated by this formula compare well with the experimental data.

V. D. Sokolov

Courtesy Referativnyi Zhurnal, USSR

4671. Weintraub, M., Flow of fluids, *Indust. Engng. Chem.* **52,** 257–261 (Unit Operations Review), Mar. 1960.

Compressible Flow (Continuum and Noncontinuum Flow)

(See also Revs. 4561, 4654, 4671, 4699, 4712, 4713, 4717, 4718, 4719, 4724, 4725, 4729, 4731, 4733, 4734, 4738, 4742, 4745, 4751, 4752, 4754, 4759, 4772, 4782, 4783, 4784, 4793, 4820, 4839, 4843, 4868, 4895, 4911, 4913)

4672. Sretenskii, L. N., On Chaplygin functions, *Appl. Math. Mech.* (*Prikl. Mat. Mekh.*) **23,** 3, 807–810, 1959. (Pergamon Press, Inc., 122 E. 55th St., New York 22, N. Y.).

The equation satisfied by the stream function in steady plane-parallel potential flow of a gas expressed in Chaplygin's variables θ, τ has a particular solution of the form $z_n(\tau) \sin(n\theta + \alpha)$. Taking $\beta = 1/(\gamma - 1)$ equal to 2.5, the value for air, author solves a diophantine equation for n to obtain integers for which $z_n(\tau)$ can be expressed in terms of elementary functions.

L. M. Milne-Thomson, USA

4673. Van Dyke, M. D., Second-order slender-body-theory axisymmetric flow, NASA TR R-47, 26 pp., 1959.

See AMR **12**(1959), Rev. 3457.

4674. Sinil'nikova, O. L., Change of pressure in an extensive gas conduit when the flow of gas is not steady (in Russian), *Gaz. Prom-st'* no. 5, 48–50, 1958; *Ref. Zh. Mekh.* no. 2, 1959, Rev. 1309.

The problem is solved regarding the change in gas pressure in the main with a variable withdrawal of gas from the conduit at one end and a simultaneous constant inflow of gas at the other. In the equations of the even motion of an incompressible gas in the isentropic process

$$-\frac{\partial p}{\partial x} = \frac{\partial(\rho u)}{\partial t} + \frac{\lambda \rho u^2}{2D}$$

a linearization of the third term takes place. It is assumed that $\lambda u/2D$ is a constant. The solution of the simplified system of equations (input, impulse and condition) has the form

$$(\Delta p)_{x=L} = \frac{2\gamma_0 L a \Delta Q}{gF}\left(1 - \frac{8}{\pi^2} e^{-\frac{\pi^2}{2a^2} at}\right)$$

where ΔQ is the increment of volume of the gas being removed at the end of the conduit, L the length of the pipeline, γ_0 the acceleration of the force of gravity, F a section of the gas pipe. The calculations for the change of pressure carried out with the derived formula agree well with the results of measurements made on the gas main Dashava-Kiev. V. D. Sokolov

Courtesy Referativnyi Zhurnal, USSR

4675. Chirkov, A. A., The principle of changes of pressure in the section of a free and a restricted stream (Some new concepts for the evolution of a theory of ejection) (in Russian), *Trudi Rostovsk. In-ta Inzb. Zb.-d. Transp.* no. 21, 137–155, 1958; *Ref. Zh. Mekh.* no. 2, 1959, Rev. 1345.

The author, using the equations of expenditure, the quantity of motion and energy, and working in accordance with the experimental fields of temperatures and concentrations, determines the field of static pressures in the transverse section of the initial part of a jet of a subsonic gas ejector. The presence of differences of temperatures, concentrations and velocities in the ejected and ejecting gases leads to the position where the static pressure in the transverse section of the initial part of the restricted jet becomes variable, a matter confirmed by the experiments of a number of authors. V. D. Sokolov

Courtesy Referativnyi Zhurnal, USSR

4676. Vulis, L. A., Mironenko, T. K., and Terekhina, N. N., An approximate calculation for the determination of the velocities and temperatures in the free turbulent jets of a compressible gas (in Russian), Investigations of the physical bases of the working process of furnaces and ovens (Issled. Fiz. Osnov Rabochego Protesessa Topok i Pechei) Alma-Ata, Akad. Nauk KazSSR, 1957, 148–165; *Ref. Zh. Mekh.* no. 2, 1959, Rev. 1349.

A method is expounded for the approximate computation of the mechanism of propagation of free turbulent jets of a compressible gas, based on the assumption regarding the similarity of the consistency of the impulse flows, the surplus heat content, the concentration, and so forth [see L. A. Vulis, "Investigations of the physical bases of the working process in furnaces and ovens," Alma Ata, Akad. Nauk KazSSR, 1957, 15–53] for a few self-modelling motions. Results are given for the calculation for the edge of a jet, for a free plane jet and for an axially symmetrical slightly twisted jet with a Prandtl number for turbulent mixing $\sigma_T = 0.75$ for various values for the parameter of compressibility ω equal to the relation of the density of the gas in the surrounding medium to its density in the jet. The influence is analyzed of the parameter of compressibility on the velocity profile and the excess temperature in a jet of small velocity and also in a jet of large velocity. Solutions are used, as initial solutions, for the corresponding motions of an incompressible liquid. A. S. Ginevskii

Courtesy Referativnyi Zhurnal, USSR

4677. Hussein-Zadé, M. A., The problem of the subsonic flow of a perfect fluid round a permeable airfoil (in Russian), *Vestn. Mosk. In-ta* no. 5, 35–37, 1953; *Ref. Zh. Mekh.* no. 8, 1958, Rev. 8508.

In a more general form, a solution is given for the problem of the flow around a thin, permeable profile, discussed by Kh. A. Rakhmatulin in *Vestn. Mosk. In-ta* no. 3, 1950. The singular integral equation for the intensities of the vortices replacing the permeable

surfaces is written in nondimensional quantities in the following form:

$$A_\gamma(\bar{x}) + \frac{B}{\pi i}\int_0^1 \frac{\gamma(\bar{\zeta})\,d\bar{\zeta}}{\bar{\zeta} - \bar{x}} = f(\bar{x}) \qquad [2]$$

$$A = \frac{\rho V_\infty}{\alpha\sqrt{1 - M^2}}, \quad f(x) = \frac{v_0\beta_{(x)} + \lambda}{\sqrt{1 - M^2}}$$

$$B = \frac{i}{2}, \quad \bar{x} = \frac{x}{l}, \quad \bar{\zeta} = \frac{\zeta}{l}$$

α, λ, characteristic parameters of the surface. Author analyses the case

$$f(\bar{x}) = B_0 + B_1\bar{x} + B_2\bar{x}^2 + \ldots + B_n\bar{x}^n$$

The solution found, satisfying the condition of a finite value of $\gamma(0)$, is in the following form:

$$\gamma(\bar{x}) = 2\left(\frac{\bar{x}}{1 - \bar{x}}\right)^m \left\{B_0 + \sum_{i=1}^{n} B_i \sum_{k=0}^{i} (d_i)^{(k)} \frac{\bar{x}^k}{k'}(-1)^{i-k} x \right.$$

$$\left. x\,\frac{(k+m)\ldots(k+m-i+1)}{i!}\sin m\pi\right\}$$

$$d_i = 1 + \bar{x} + \bar{x}^2 + \ldots + \bar{x}^i$$

It is demonstrated that, for the case of a flat plate, the solution coincides with that found by Rakhmatulin.

G. G. Tumashev

Courtesy Referativnyi Zhurnal, USSR

4678. Schatz, R., Riemann's problem for a Laval-nozzle, Part 1, Hydraulic approximation, AFOSR TN 59-709 (Math. Inst. Technische Hochschule Munchen TN-9), 23 pp., Aug. 1959.

Part I presents an iterative modification of the method of finite differences for the solution of quasi-one-dimensional, nonsteady, isentropic flow problems. [See Rudinger, G.: "Wave diagrams for non-steady flow in ducts," D. Van Nostrand Company, Inc., New York, 1955, and the references cited therein for earlier discussions of numerical solutions of such flow problems.) The method is employed to determine the flow in the high pressure, "Laval nozzle" side of a modified shock tube. Numerical results and a discussion of convergence of the finite difference method conclude the paper.

The forthcoming Part II is to present the solution of the same problem obtained by the method of Bruhn and Haack in which the quasi-one-dimensional flow assumption is not made [see *ZAMP* **XI**b (1958), "Ein Charakteristikenverfahren für dreidimensionale instationäre Gasstromüngen"]. Author's purpose is to assess the accuracy of the quasi-one-dimensional flow approximation.

H. P. Eichenberger and E. L. Krasnoff, USA

4679. Crigler, J. L., A method for calculating aerodynamic loadings on thin wings at a Mach number of 1, NASA TN D-96, 30 pp., Nov. 1959.

Analysis is based on the linearized theory of compressible flow. Calculation of the forces on a wing depends on the solution of an integral equation which relates the lift and downwash distributions. The unknown lift is expressed as a series of terms involving certain unknown coefficients. Presented method is similar to author's former publication [AMR **10**(1957), Rev. 2969] but differs from previously developed lifting-surface procedures in that the chordwise integrations can be performed analytically for the special case of $M_0 = 1.0$. Thus the need for any approximate or numerical procedure is eliminated. The spanwise integrations are then performed by numerical procedures.

Calculations of the magnitude and distribution of the spanwise loading for a thin sweptback wing at a Mach number of 1.0 show good agreement with experimental data of a wing-body combination at Mach numbers of $M_0 = 0.98$ and $M_0 = 1.03$. According to investigations made in [AMR **10**(1957), Rev. 2969] for a wing alone and for a wing-body combination author believes that the loadings on the more important outboard sections of the wing were not essentially affected by the presence of the body.

G. A. Altmann, Germany

4680. Drougge, G., An experimental investigation of the interference between bodies of revolution at transonic speeds with special reference to the sonic and supersonic area rules, Flygtekn. Försöksanst. Medd. 83, 37 pp., 1959.

Author presents the results of wind-tunnel experiments at Mach numbers 0.8 ~ 1.15 on bodies of revolution generated by parabolic arcs with vertex at the point of maximum thickness. The investigation consists of three main parts. The first part deals with the pressure distribution and the drag of the single body, and the results verify the transonic similarity rule. In the second part the validity of the sonic and supersonic area rules is investigated by measuring the interference between a pair of bodies of revolution. Based on the supersonic area rule, author derives a formula for the variation of the drag coefficient with lateral distance between two bodies. Agreement with experiments is satisfactory at $M_\infty = 1.15$. Experiments for $M_\infty = 1$ are in good agreement with the theory given in the appendix by S. Berndt and L. Hilding. The third part is the application of the area rule to the problem of finding low drag configurations with two or three adjacent bodies. Results show large drag reduction and good agreement with supersonic area rule computation.

In the appendix entitled "Application of the transonic principle of equivalence to a pair of bodies of revolution," Berndt and Hilding present theoretical formulas for the pressure distribution and the drag coefficient for the case of two interfering bodies at transonic speeds. Similarity rule for such bodies is also considered.

F. Tamaki, Japan

4681. Thommen, H. U., On transonic flow about slender three-dimensional bodies, AFOSR TN 58-714 (Brown Univ., Div. Engng. Tech. Rep. WT-27; ASTIA AD 162 249), 135 pp., Sept. 1958.

The nonlinear differential equation for the perturbation potential of transonic flow about slender three-dimensional bodies is transformed into a nonlinear integral equation by means of multiple Fourier transforms. Two parameters are introduced and an attempt is made to choose these parameters locally, such that the nonlinear integral equation can be approximated by a linear one. The approximate linear integral equation is of the type of conventional linear perturbation theory, but kernel function is different. It contains, however, kernel functions of linear subsonic and supersonic theory as special cases.

The integral equation is solved for slender bodies of revolution at small angles of attack. Numerical evaluation has been carried out on an IBM 650 electronic computer.

Pressure distributions have been measured on a family of three half bodies of revolution with parabolic nose section in the Brown University 9-in. by 9-in. transonic wind tunnel. Tests were carried out with (a) longitudinally slotted and (b) perforated walls for Mach numbers from 0.50 to 0.90 in steps of one tenth and from 0.95 to 1.05 in steps of 0.025.

From author's summary by F. W. Riegels, Germany

4682. Peischl, F., and Stetter, H. J., Linear supersonic flow past combinations of a cylindrical body and triangular wings, AFOSR TN 59-1160 (Mathematical Institute Technische Hochschule Munchen TN-11), 28 pp., Nov. 1959.

For an infinite cylindrical body of revolution with a plane delta wing the pressure distribution has been calculated for supersonic flow by linear theory. The delta wing has supersonic leading edges. It has been possible to find the pressure distribution with linear theory without further approximations. After having studied the quasi-cyclindrical wing-body interference authors solved the nontrivial second step of the procedure by analytical method. The solution is numerical, computed by Fourier analysis with aid of the PERM electronic computer of the technical university at Munich. Results of pressure distribution for several cases are shown in diagrams and are discussed.

F. W. Keune, Germany

4683. Thomann, H., Measurement of the recovery temperature in the wake of a cylinder and of a wedge at Mach numbers between 0.5 and 3 (in English), Flygtekn. Försöksanst. Medd. 84, 21 pp., 1959.

Recovery factors were measured in the wake and on the base of a circular cylinder and a wedge spanning the tunnel. Measurements were made of subsonic, transonic and supersonic speeds at Reynolds numbers between 0.6×10^5 to 3×10^6. It was found that the recovery factor is greatly influenced by the formation of the vortex sheet in subsonic flow. The suppression of the vortex sheet by a splitter plate increased the recovery factor from 0 - 0.2 to 0.8 - 0.9. In the transonic and supersonic speeds where the vortex sheet disappears, measured recovery factors were again 0.8 - 0.9.

The temperatures were measured by copper-constantan thermocouples surrounded by balsa wood insulation and inserted into the model. The wake temperatures were measured on the tunnel side wall, which was made of plexiglass and thermally insulated from the outside.

Vortex frequency was measured by light fluctuation of the schlieren image on a photocell.

The wake is expected to be turbulent and no effect of Reynolds number in this range is noted. J. Rabinowicz, Israel

4684. Ginoux, J. J., Laminar separation in supersonic flow with emphasis on three-dimensional perturbations at reattachment, AFOSR TN 60-237 (Brussels Univ., TCEA TN 3), 42 pp., Feb. 1960.

It was shown that regular and repeatable spanwise flow perturbations existed in the reattachment region of a laminar supersonic boundary layer on a two-dimensional backward-facing step model. It was found that the model span and leading-edge thickness, when below 0.1 mm, had no effect on the wavelength of the flow perturbations.

On backward facing-steps, at a Mach number of 2.16, the ratio of wavelength of the flow perturbations to boundary-layer thickness was a function of the ratio of step-height to boundary-layer thickness.

Similar perturbations were found at the reattachment region of a laminar boundary layer on forward-facing steps, on compression-corners, on rectangular cavities and in the case of interaction between a shock wave and the boundary layer. They were also detected in unseparated boundary-layers.

The presence of three-dimensional perturbations seems to be related to the general question of boundary-layer stability.

From author's summary

4685. Semerchan, A. A., Vereshchagin, L. F., Isaikov, V. K., and Firsov, A. I., Hydraulic installation for obtaining supersonic velocity jets of liquids, *Instruments and Experimental Techniques* no. 1, 125-129, Jan. 1960. (Translation of *Pribory i Tekhnika Eksperimenta USSR* no. 1, 121-124, Jan./Feb. 1959 by Instrument Society of America, Pittsburgh 22, Pa.)

4686. Hall, J. G., and Russo, A. L., Studies of chemical nonequilibrium in hypersonic nozzle flows, AFOSR TN 59-1090 (Cornell Aero. Lab. Rep. AD-1118-A-6), 59 pp., Nov. 1959.

A numerical analysis, using a digital computer, of steady nozzle flow of dissociated diatomic gas (oxygen with inerts) wherein a single dissociation-recombination reaction occurs. Quasi-one-dimensional flow with finite reaction rates and zero transport properties are assumed. All solutions presented exhibit rapid freezing of the oxygen composition downstream of the nozzle throat. Increased reservoir pressure delays freezing while temperature dependence of the recombination rate appears to have a small influence on freezing. Analytical approximations are discussed and application to wind tunnels and rockets are examined.

R. A. Gross, USA

4687. Hayes, W. D., Newtonian flow theory in hypersonic aerodynamics, Advances in Aeronautical Sciences, Vol. 1 (Proc. of the First International Congress in the Aeronautical Sciences, Madrid, Sept. 8-13, 1958), New York, Pergamon Press, 1959, 113-119.

A brief description is given of the body of theory known as Newtonian flow theory, the theory based on the assumption that the shock layer in a hypersonic flow is infinitesimally thin. The reasons why the study of this theory is essential to an understanding of hypersonic aerodynamics are emphasized.

The accomplishments of Sir Isaac Newton in gas dynamics are discussed, together with the development of the pressure laws referred to as Newtonian. Some of the features of the general theory are discussed, including optimum shapes for minimum drag and solutions with cross flow. From author's summary

4688. Ferri, A., A review of some recent developments in hypersonic flow, Advances in Aeronautical Sciences, Vol. 2 (Proc. of the First International Congress in the Aeronautical Sciences, Madrid, Sept. 8-13, 1958), Pergamon Press, 1959, 723-770.

4689. Sakurai, T., On the normal shock wave attached to the curved surface, *J. Aero/Space Sci.* **26**, 7, 460-461 (Readers' Forum), July 1959.

A contradiction is resolved between the results of Zierup [see: *ZAMP* **9b**, pp. 764-776, 1958] and those of Lin and Rubinov [see: *Math. Phys.* **27**, pp. 105-129, 1948] concerning the existence of a normal shock configuration for a convex surface in the Mach number region $M = 1 \sim 1.662$. It is shown that Zierup's condition on a normal velocity derivative is untenable. The correct condition leads to agreement on the nonexistence of the configuration.

A. Sowyrda, USA

4690. Pritchard, H. O., Shock waves, *Quart. Rev. Chem. Soc. Lond.* **14**, 1, 46-61, 1960.

A survey of the chemical applications of shock waves.

Ed.

4691. Adamskii, V. B., and Popov, N. A., The motion of a gas under the action of a pressure on a piston, varying according to a power law, *Appl. Math. Mech. (Prikl. Mat. Mekh.)* **23**, 3, 793-806, 1959. (Pergamon Press, Inc., 122 E. 55th St., New York, N. Y.).

Authors analyze the one-dimensional pressure distribution in a gas, occuring when a piston, actuated by a variable pressure $p = p_0(t_0/t)^{\alpha}$, releases a shock wave. Analysis is concerned with entire region between piston and preceding shock wave. In reviewer's opinion, the paper is of questionable value; the second equation, preceding Eq. [1.2], is not the correct equation for propagation of a shock wave, but is an approximation for large values of the shock strength. However, authors' discussion is not confined to strong shocks, since they consider all values of α, including

cases where the pressure is zero at $t = 0$. Therefore, the validity of the authors' conclusions seems, to this reviewer, doubtful except, perhaps, in the region of strong shocks.

E. F. Lype, USA

4692. Godunov, S. K., A method of differences for the analysis of shock wave forms (in Russian), *Uspekhi Matem. Nauk* **12**, 1, 176–177, 1957; *Ref. Zh. Mekh.* no. 9, 1958, Rev. 9567.

Neumann and Richtmyer [*J. Appl. Phys.* **21**, 3, 232–237, 1950; AMR **4**(1951), Rev. **775**] and Lax [*Comm. Pure Appl. Math.* **7**, 1, 159–193, 1954] proposed the use of difference methods for calculating hydromechanical equations.

Present author presents a new and more accurate scheme for the analysis of discontinuous solutions of a system of equations describing the unidimensional motion of a perfect gas:

$$\frac{\partial u}{\partial t} + \frac{\partial p(v, E)}{\partial x} = 0, \quad \frac{\partial v}{\partial t} - \frac{\partial u}{\partial \chi} = 0,$$

$$\frac{\partial \left(E + \frac{u^2}{2}\right)}{t} + \frac{\partial (pu)}{\partial \chi} = 0$$

wherein u is velocity, p pressure, v specific volume, E specific internal energy, χ Lagrange coordinate. The essence of the method is as follows: The gas is resolved into layers of mass $\Delta\chi$ each. In each layer, at the starting time instant t_0, the quantities u, v, E, are assumed to be constant. In view of the presence of the different values of u and p on either side of the boundary between two adjacent layers, the initial discontinuity will break down, and a velocity U and pressure P will be formed at the boundary. Inspecting the time interval τ during which all values of U and P remain constant, then the mean values of the quantities u, v, E in each layer at the end of such time value can be calculated from the conservation equations.

The resulting values of $u(t_0 + \tau)$, $v(t_0 + \tau)$, $E(t_0 + \tau)$ are used as starting data for the next step.

For calculating U and P, an iteration process is available, or a number of approximation formulas. The results of calculations by this method are compared with those obtained by the method of characteristics. Coincidence is satisfactory.

E. V. Ryazanov

Courtesy Referativnyi Zhurnal, USSR

4693. Arynov, A., The steady relativistic flow of gas with axial symmetry (rotational case), *Soviet Phys.-Doklady* **4**, 2, 267–270, Oct. 1959. (Translation of *Doklady Akad. Nauk SSSR (N. S.)* **125**, 3, 512–513, Mar./Apr. 1959 by Amer. Inst. Phys., Inc., New York, N.Y.)

Boundary Layer

(See also Revs. 4390, 4627, 4652, 4660, 4661, 4683, 4686, 4755, 4787, 4818, 4819, 4823, 4826, 4870, 4919)

4694. Becker, E., Calculation of boundary layers with small secondary flow, using the momentum theorem (in German), *Z. Flugwiss.* **7**, 6, 163–175, June 1959.

The momentum method is applied to the computation of the secondary flow in a boundary layer, under the assumption that the secondary flow can be considered as a first-order perturbation. Method is illustrated by examples of laminar and turbulent flow. An error in the basic formulas occurring in the literature is rectified.

K. G. Guderley, USA

4695. Azad, A. K., Elementary analysis of the turbulent plate layer, Washington, D. C., Catholic Univ. of Amer. Press, Jan. 1959, 10 pp.

A theory of turbulence due to Max Munk is applied to the case of a boundary layer on a flat plate in zero pressure gradient. According to the theory, which applies neither near the wall nor in the outermost part of the boundary layer, the velocity distribution satisfies a nonlinear partial differential equation of the second order. This had previously been solved by Munk for pipe flow, and is solved approximately for the plate in the present paper. The computed change in characteristics of the velocity profile between the pipe and plate agrees well with experiment, comparison with which yields numerical values of two constants occurring in the theory.

L. Landweber, USA

4696. Smith, D. W., and Walker, J. H., Skin-friction measurements in incompressible flow, NASA TR R-26, 35 pp., 1959.

Experiments have been conducted to measure the local surface-shear stress and the average skin-friction coefficient in incompressible flow for a turbulent boundary layer on a smooth flat plate having zero pressure gradient. Data were obtained for a range of Reynolds numbers from 1 million to 45 million. The local surface-shear stress was measured by a floating-element skin-friction balance and also by a calibrated total head tube located on the surface of the test wall. The average skin-friction coefficient was obtained from boundary-layer velocity profiles.

See also AMR **11**(1958), Rev. 3728.

From authors' summary

4697. Solodkin, E. E., and Ginevsky, A. S., The turbulent flow of a viscous fluid in the entry sections of axially-symmetrical and two-dimensional channels (in Russian), *Trudi Tsentr. Aero-Gidrodinam. In-ta* no. 701, 57 pp., 1957; *Ref. Zh. Mekh.* no. 8, 1958, Rev. 8889.

An approximate solution is presented for the problem of the turbulent boundary layer and the flow resistance, i.e. the entry lengths of an axially symmetrical, divergent channel with zero pressure gradient, and a two-dimensional channel. Consideration is given to the influence of transverse curvature of the surface of the channel on the velocity profile, local coefficient of friction, and the other characteristics of a turbulent boundary layer. It has been assumed that in the entry section of the channel the velocity is constant, while the static pressure is invariable across the boundary layer. From analysis of the differential equations describing the mean steady flow in the turbulent boundary layer of the channel flow it is demonstrated that in the vicinity of the surface and with accuracy to the third-order terms, the distribution of the shearing stresses across the layer is governed by the condition $r\tau = \text{const} = r_0\tau_0$; where r and r_0 are the corresponding radii of an element of the fluid in the boundary layer and the channel cross section; τ and τ_0, the frictional stresses in the boundary layer and the surface of the channel flow, respectively. In conjunction with the Prandtl relationship

$$\tau = \rho l^2 (\partial u/\partial y)^2$$

where ρ is density of the fluid, l mixing length, $\partial u/\partial y$ gradient of the mean flow velocity in the direction normal to the wall, this enables an equation to be set up for the velocity profile in the turbulent boundary layer of an axially symmetrical channel, which for $r_0 \to \infty$ becomes the familiar logarithmic velocity profile of the turbulent layer on a flat plate. In the immediate vicinity of the channel wall the velocity distribution is obtained by the assumption of a laminar substratum in which $\tau = \mu \partial u/\partial y$, μ being the viscosity coefficient of the fluid. The law of the flow resistance is obtained as the result of equating both velocity distributions on the boundary of the laminar substratum. The thickness of the laminar substratum is determined from the ordinary relationship, $\delta^* = \alpha_1 \nu/v_*$, where $\nu = \mu/\rho$. The calculations have been made for values of the coefficients of turbulence, k_1 and α_1, corresponding to the values for flat plates: $k_1 = 0.392$, $\alpha_1 = 11.5$.

As a result of integrating the equations of momentum, the aerodynamic characteristics of an axially symmetrical, divergent channel with zero pressure gradient are obtained for various values of the Reynolds number, and the influence of transverse curvature of the concave surface on the characteristics of the boundary layer is analyzed, it being demonstrated that, on account of the curvature of the surface, the velocity profile becomes less full; when, consequently, the coefficient of frictional resistance decreases compared with the case of a flat surface. At the same time, the influence of transverse curvature of the surface becomes particularly significant as the ratio δ/r_0 approaches unity.

The data obtained have further been applied to solving the problem of the entry length of a circular pipe. In this, the influence of the longitudinal pressure gradient is considered only in the equation of momentum. From the solution of the problem the aerodynamic characteristics of the entry length of a circular pipe are derived, including the value of the entry length for several different values of the Reynolds number. The length of the entry section of a circular pipe found in this manner is nearly three times the length obtained by calculation from an exponential velocity profile (the Latsko theory) and twice the length obtained by calculation from a logarithmic velocity profile (the Shablevsky theory); while being, at the same time, very close to the corresponding length obtained experimentally (Kirsten's experiment).

In conclusion, the calculation is demonstrated of the aerodynamic characteristics of the entry length of a two-dimentional channel for a logarithmic velocity distribution in the boundary layer. Since the circular and the two-dimensional pipe are the two limiting cases of an annular pipe, the relationships of the aerodynamic characteristics of these pipes to the length of the channel are plotted in a single chart. It is shown that, if the hydraulic radius of the channel is taken as a characteristic linear dimension, the indicated relationships for the circular and two-dimensional pipes practically coincide; i.e., they can be used to determine the characteristics of the entry length of a pipe of annular cross section.

V. I. Yagodkin

Courtesy Referativnyi Zhurnal, USSR

4698. Shkadov, V. Ya., Integration of the boundary-layer equations, *Soviet Phys.-Doklady* **4**, 3, 585–588, Dec. 1959. (Translation of *Doklady Akad. Nauk SSSR (N.S.)* **126**, 4, 730–733, May/June 1959 by Amer. Inst. Phys., Inc., New York, N. Y.)

Author extends the method of L. Howarth [*Proc. Roy. Soc. Lond.* (*A*) **164**, pp. 547–549, 1938] to plane compressible flow, first for a profile at constant temperature (T = const for $y = 0$), then for a nonconducting profile ($T_y = 0$ for $y = 0$). In this summary no convergence proofs are given, and numerical methods are not discussed.

P. M. Treuenfels, USA

4699. Scala, S. M., and Workman, J. B., The stagnation-point boundary layer on a rotating hypersonic body, *J. Aero/Space Sci.* **26**, 3, p. 183 (Readers' Forum), Mar. 1959.

Authors examine stagnation-point boundary-layer equations for an axially symmetric rotating body. They show that, in order to neglect the effects of body spin, the ratio of the square of the angular velocity to the square of the stagnation point velocity gradient along the surface must be small compared with unity. Making a high Mach number approximation that the product of nose radius and stagnation point velocity gradient is proportional to the square of the free-stream velocity (the constant of proportionality is dimensional), authors conclude that extremely high spin rates would be necessary for spin effects to be important in the region of the stagnation point.

I. Greber, USA

4700. Arkhipov, V. N., Stability of a laminar accompanying region (in Russian), *Vestnik Mosk. In-ta, Ser. Mat., Mekh. Astron. Fiz. Khimii* no. 4, 41–44, 1957; *Ref. Zh. Mekh.* no. 2, 1959, Rev. 1517.

A solution is found, using Galerkin's method, for the stability of a plane-parallel laminar traveling zone while taking into account the viscosity. As exemplifying the profile of the velocity of the original flow a profile is adopted which is characteristic of a traveling zone beyond a round cylinder. The calculation for the antisymmetrical disturbances gave a critical value for the Reynolds number of 36.5 and a value for the Strouhal number of 0.13 which agreed well with the experimental. For symmetrical disturbances the critical value for R was greater than for unsymmetrical ones.

I. P. Suprunenko

Courtesy Referativnyi Zhurnal, USSR

4701. Gortler, H., Some recent contributions to the hydrodynamic stability theory (in German), *Z. Flugwiss.* **8**, 1, 1–8, Jan. 1960.

A brief presentation is given of the theoretical research work carried out at Freiburg/Breisgau during recent years on the theory of hydrodynamic stability. The report addresses itself to the interested non-specialists and lays emphasis on the physical side, while touching the mathematical complexities only in passing. The investigations treated are aimed at making contributions to a deepened and more general understanding of the mechanism of the transition from laminar to turbulent flows.

From author's summary

4702. Pearcey, H. H., The occurrence and development of boundary-layer separations at high incidences and high speeds, Aero. Res. Counc. Lond., Rep. Mem. 3109, 15 pp., 1960.

This note describes the manner in which the onset of the effects of boundary-layer separation varies with Mach number for two-dimensional airfoils, and discusses the influence of section shape as far as it is known. A brief qualitative description is given of the mechanism underlying the development of the separated flow and its effects, followed by a discussion of some of the ways in which this is likely to differ for sweptback wings at high speeds. Finally, the need is emphasized for continued work in a broadening field.

From author's summary

4703. Ryan, N. W., and Johnson, M. M., Transition from laminar to turbulent flow in pipes, *AIChE J.* **5**, 4, 433–435, Dec. 1959.

In pipeline design, for which one needs a means of ascertaining whether the flow will be laminar or turbulent, the Reynolds number is the criterion for Newtonian fluids. The principal purpose of this study was to formulate a more general criterion to characterize the flow regime and to test this form in application to non-Newtonian fluids.

Intuitive physical arguments suggested the use of a local stability parameter which is a function of the ratio of input energy to energy dissipation for an element of fluid. If the parameter is applied to a Newtonian fluid in laminar pipe flow, one finds that it has a maximum value of 0.385 times the critical Reynolds number, or 808. As the criterion is presumed to be general, it is inferred that the value of 808 defines the boundary between stable laminar and stable turbulent pipe flow for all fluids. The inference has been varified for several pseudoplastic fluids.

From authors' summary

4704. Hama, F. R., Some transition patterns in axisymmetric boundary layers, *Physics of Fluids* **2**, 6, 664–667, Nov./Dec. 1959.

Direct observation of the vortex pattern caused by a ring-shaped trip is made on 1-in. and 1/2-in. circular cylinders and on a 30° cone in a water tank. Over the cylinders the boundary-layer thickness is approximately equal to the radius of the cylinders. Ring-shaped vortices are shed and deformed into vortex loops in the same manner as on a flat plate. On the cone the ring-shaped vortices are stretched and then inevitably deformed into vortex loops, indicating that a mere stretching is not a sufficient mecha-

nism for the creation of a turbulence spot. A mechanism of the final breakdown from the vortex loop is tentatively proposed.

From author's summary

4705. Sergienko, A. A., and Gretsov, V. K., Transition from a turbulent into a laminar boundary layer, *Soviet Phys.-Doklady* **4,** 2, 275–276, Oct. 1959. (Translation of *Doklady Akad. Nauk SSSR (N.S.)* **125,** 4, 746–747, Mar./Apr. 1959 by Amer. Inst. Phys., Inc., New York, N. Y.)

The phenomenon of transition from turbulent flow in a boundary layer to laminar flow is shown. Air was supplied under pressure to a 1-m long cylindrical tube of 76-mm diameter, in which was positioned an axisymmetric nozzle giving a Mach number of 2.6 to the exit air. The boundary layer was studied at the end of the tube, i.e. immediately in front of the nozzle, and at the nozzle outlet.

In the tube the boundary layer became turbulent and was thus turbulent at the entrance to the nozzle. At the nozzle outlet, however, a supersonic laminar boundary layer was obtained. This demonstrated that a "reverse" transition took place, probably in the subsonic portion of the nozzle where a large negative pressure gradient existed. At an increased Reynolds number, which was obtained by increasing the pressure of the supply from 0.3 to 1.0 kg/cm^2, a turbulent boundary layer appeared at the nozzle outlet.

E. Petersohn, Sweden

4706. Bhatnagar, P. L., Sankar, R., and Jain, A. C., Boundary layer on a flat plate with suction, *Proc. Indian Acad. Sci. (A)* **51,** 1, 1–13, Jan. 1960.

The problem of laminar incompressible flow around a flat plate with continuous suction is investigated for the vicinity of the leading edge and for a downstream section of the plate. For the leading edge a linear law of suction distribution is assumed. The theory is developed on the basis of the full Navier-Stokes equations by means of a series expansion for the stream function. Analytical expressions for the first two terms are derived. An undetermined constant appearing in the solution is obtained by comparing the result for the case with no suction with the Blasius solution.

The flow further downstream is treated on the basis of the boundary-layer equations. In this case no restriction is made for the suction velocity. The solution is presented in the form of a power series. One of its coefficients was obtained from the Blasius solution, the others can be calculated by a recurrence formula.

The authors succeed in giving explicit expressions for the boundary-layer thickness and the skin-friction in terms of the suction velocity and the distance from the leading edge.

W. Pechau, Germany

4707. Head, M. R., Approximate calculations of the laminar boundary layer with suction, with particular reference to the suction requirements for boundary-layer stability on aerofoils of different thickness/chord ratios, Aero. Res. Counc. Lond. Rep. Mem. 3124, 19 pp., 1959.

In an earlier report [R and M 3123, 1957, not reviewed in AMR] author developed a method for computing laminar compressible boundary layers by satisfying both the momentum and energy integral equations of the boundary layer ("essentially a development of one given earlier by K. Wieghardt [*Ing. Arch.* **16,** p. 231, 1948]"). In part I of the present report this method is used to study (a) flat plate with uniform suction and sinusoidal variation of external velocity, (b) flat plate with intermittent suction, (c) suction applied following the normal separation point to maintain a zero skin-friction layer for the flow $U = 1 - x$, (d) flat plate with uniform blowing. In part II a series of airfoils (NACA 65$_4$-021 with varying thickness ratio) is considered. Suction is applied to delay or avoid separation of the layer. The suction distributions for maintaining neutral stability of the layer are computed as functions of thickness/chord ratio and Reynolds number.

Irmgard Flügge-Lotz, USA

4708. Kulonen, G. A., Shock wave-boundary layer interaction in the neighborhood of the leading edge of a flat plate at hypersonic speeds taking radiant energy into account (in Russian), *Vestnik, Leningrad Univ., Math. Mech. Astron.* no. 7, issue 2, 172–188, 1958. (Translated by Morris D. Friedman, P.O. Box 35, W. Newton, Mass., K-144, 18 pp.)

Inclination of the shock at the leading edge of a slender body at hypersonic speeds is small enough that viscous friction forces can substantially influence the gas flow in the vicinity of the edge between the shock wave and the body. Several authors have studied the hypersonic flow in interaction region: (1) Shen, *J. Aero. Sci.* **19,** no. 7, 1952; (2) Lees, *J. Aero. Sci.* **20,** no. 2, 1953; and (3) Li, *J. Aero. Sci.* **20,** no. 5, 1953. Series expansion method was used in (1); the case for $P_r = 1$ with and without heat transmission was studied in (2); and a heat-insulated surface was studied in (3). This paper is an attempt to account for the radiant energy in this region and indicates it may influence surface temperature, skin friction and the velocity profile.

S. Lampert, USA

4709. Sage, B. H., Some aspects of fluid mechanics in chemical engineering, *AIChE J.* **5,** 3, 331–338, Sept. 1959.

The prediction of the transfers of momentum, energy, and material is of ever-pressing concern to the engineer interested in process design. Recently developed facts concerning the transport of momentum which are of particular use in predicting transfers of energy and material are reviewed, as well as the background of thermodynamics associated with transport processes. The more elemental relationships pertaining to thermal and material transfer in flowing streams are considered, and some of the interrelations of the transport processes are presented.

From author's summary

Turbulence

(See also Revs. 4390, 4627, 4643, 4652, 4661, 4676, 4695, 4697, 4705, 4776, 4821, 4822, 4843, 4919)

Book—4710. Batchelor, G. K., The theory of homogeneous turbulence, New York, Cambridge University Press, 1959, xi + 197 pp. $3.75. (Paperbound)

This is a students' edition reprinted from the 1953 edition. See AMR **6** (1953), Rev. 2855. Ed.

4711. Nevzglyadov, V. G., On the turbulent energy flux vector, *Soviet Phys.-Doklady* **4,** 1, 43–45, Aug. 1959. (Translation of *Doklady Akad. Nauk SSSR (N.S.)* **124,** 2, 288–290, Jan./Feb. 1959 by Amer. Inst. Phys., Inc., New York, N. Y.)

Author postulates that the flux of turbulent energy (in any turbulent flow) is equal to the product of the spatial gradient of turbulent energy multiplied by a (tensor) effective diffusivity. The purpose of the paper is to suggest various plausible forms of the expression for this diffusivity in terms of more fundamental quantities such as the Reynolds stress tensor and the mean rate-of-strain tensor.

G. K. Batchelor, England

4712. Craven, A. H., The effect of density on jet flow at subsonic speeds, Coll. Aero., Cranfield, Rep. 120, 20 pp., July 1959.

The problem of the turbulent mixing of a gas jet issuing into a second gas is treated quite generally. The results for the particular case of a jet issuing into a gas at rest are equivalent to those

found by Blottner. The velocity and density profiles across the jet are, beyond the potential core, expressed in the form: $u = u_m(x) \cdot \exp(-kz^2)$ and $c = c_m(x) \cdot \exp(-\mu kz^2)$, where ρ_1 and ρ_2 are the densities of the jet and the surrounding stream, where u_m is the velocity on the center line and c defined by: $c = (\rho - \rho_1)/(\rho_2 - \rho_1)$. k and μ depend on the two gases. The theory gives the relation between center line velocity, inflow velocity, mass flow across any section of the jet and distance downstream of the exit of the jet.

The axisymmetrical and the two-dimensional cases are treated. Values of k and μ are taken from Blottner's work [Sandia Corp. Res. & Dev. Rep. SC-4127(TR), Oct. 57]. They are used by the author not only for the axisymmetrical but also for the two-dimensional case.

Unfortunately the early work of Tollmien [*ZAMM* **6**], already given in 1926 (air jets into resting air), is not mentioned by the author. The velocity profiles of the round and the two-dimensional jet are found to be remarkedly different from each other and not of the exponential form of this work. Results of two-dimensional case remain therefore somewhat doubtful, especially because not checked by experiments. The numerical results of the axisymmetrical case are examined by experiments with jets of helium, nitrogen and carbon dioxide into resting air. There are also some experiments with jets into moving air, and rather good agreement between theory and experiment is shown. As an extreme case, the flow past a bluff cylinder is calculated and found in agreement with experiments too.

Examination of the variation of centerline-velocity with distance shows that the solution becomes inadequate for low values of the distance. This is to be expected since close to the jet the potential core exists and the assumed velocity profile does not apply.

G. Schulz, Germany

Aerodynamics

(See also Revs. 4661, 4679, 4680, 4682, 4683, 4689, 4699, 4702, 4707, 4712, 4755, 4780, 4781, 4787, 4790, 4880, 4884)

4713. Wood, A. D., Transonic flows through a straight cascade of slender airfoils, AFOSR TN 58-732 (Brown Univ., Div. Engng. Tech. Rep. WT-28; ASTIA AD 162-267), 163 pp., Aug. 1958.

The problem is changed by means of a double Fourier transform into the solution of a nonlinear integral equation. Two methods have been tried with the object of finding simple first approximations which include nonlinear effects. In the first, two parameters are introduced and chosen locally with a view to replacing the nonlinear equation by a linear one. A general solution is found for an arbitrary lifting cascade. A numerical solution is presented for a nonlifting cascade of symmetrical airfoils, but the result is not very satisfactory. A second method, used only for the investigation of the nonlifting cascade, involves making approximations in the nonlinear term of the integral equation so that it may be retained. This leads to more accurate results, when compared with experimental results measured in the Brown University transonic wind tunnel and described in the report. Finally, the flow past a fully choked nonlifting cascade has been related to the flow past a nonlifting isolated airfoil in a sonic free stream.

D. C. Pack, Scotland

4714. Malavard, L., and Hacques, G., Problems in ring airfoils, solved with rheoelectric analogies (in French), Advances in Aeronautical Sciences, Vol. 2 (Proc. of the First International Congress in the Aeronautical Sciences, Madrid, Sept. 8-13, 1958), Pergamon Press, 1959, 771-796.

4715. Salimov, P. S., Determination of profile form by means of an assigned chord diagram closely resembling the diagram of a known profile (in Russian), *Uch. Zap. Kazansk. In-ta* **117,** 9, 55-59, 1957; *Ref. Zh. Mekh.* no. 2, 1959, Rev. 1253.

To solve the problem stated in the title the proposal is made to use the method of successive approximations. The principal premises of the method, in general, are the same as in the works of L. A. Semonov [*Prikl. Mat. Mekh.* **9**, no. 1, 1947] and of G. G. Tumashev and M. T. Nuzhim [*Uch. Zap. Kazansk. In-ta* **115,** no. 6, 1955]. When solving the problem in the first approximation it is assumed that $ds/dx = ds^{(0)}/dx$; here s and $s^{(0)}$ are the lengths of the arcs of the profile being sought and of the known profile respectively, the chord diagram of which closely resembles the assigned diagram of the sought profile, x is the abscissa along the axis coinciding with the chord of the profile. The coefficients in the expression for the ordinates of the profile being sought are determined in the first and successive approximations from the conditions that the profile should have a pointed trailing edge and that its trailing and leading edges should be placed on the abscissa axis. The method enables the form of the sought profile to be determined for any required degree of accuracy; the chord of the profile, in contrast to the profiles obtained by the Semonov and Tumashev methods is always directed along the x axis.

B. N. Korozagin

Courtesy Referativnyi Zhurnal, USSR

4716. Li, T., Arc-tangent fits for pressure and pressure-drag coefficients of axisymmetric blunt bodies at all speeds, *J. Aero/Space Sci.* **27,** 4, 309-311 (Readers' Forum), Apr. 1960.

Simple empirical formulas are given for pressure coefficient and pressure-drag coefficient for axisymmetric bodies with hemispherical noses in both subsonic and supersonic airflow, at zero angle of attack.

Comparison with existing test results shows excellent agreement for all speeds. From author's summary

4717. Guiraud, J.-P., Three-dimensional hypersonic flow in a shock layer of vanishing thickness (in French), ONERA Pub. 71, 11-28, July/Aug. 1959.

A general and thorough discussion is given of three-dimensional Newtonian flow over an obstacle of arbitrary shape. The local properties of the flow are obtained from global mass and momentum balances. In this manner the Busemann pressure formula ("Newtonian-plus-centrifugal") for two-dimensional and axially symmetric flow is rederived, as is its extension to arbitrary three-dimensional shapes, previously given independently by Hayes and Guiraud. Formulas are derived for calculating total forces and moments on an arbitrary body. Several sample calculations are presented in detail. I. Greber, USA

4718. Gonor, A. L., Hypersonic gas flow around conical bodies (in Russian), *Izv. Akad. Nauk USSR, Otd. Tekh. Nauk, Mekh. i Mashino.* no. 1, 34-40, 1959. (Translated by Morris D. Friedman, P.O. Box 35, W. Newton, Mass., Gr163, 10 pp.).

Conical hypersonic inviscid flow is investigated by means of Newtonian approximation, that is with power developments in the density ratio across the shock wave. The general theory is outlined and two specific examples are worked out in some detail: the flat delta wing and the elliptic cone. In this last case some pressure distributions are given. The reviewer points out that the same problem has been investigated in general by Laval [*Rech. Aéro.* no. 75, Nov./Dec. 1959] following a related but not identical method of approach. The special case of circular cones at angles of attack had been previously investigated by the author [*Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 7, 202-205, 1958; AMR **12**(1959), Rev. 4589]. J. P. Guiraud, France

4719. Carafoli, E., and Sandulescu, S., Aerodynamic characteristics of ailerons with harmonic oscillation in supersonic flow (in French), *Rev. Mecan. Appl.* **4,** 2, 201-227, 1959.

Paper derives on purely theoretical basis some of the more important aerodynamic characteristics of an aileron oscillating with harmonic motion; apparently no test data were available for checking theory. Both subsonic and supersonic flow are considered, but primarily the latter, the analysis being based on theory of small perturbations. Several different types of aileron are studied. Paper consists almost entirely of series of complicated equations, some of which are difficult to follow in absence of table of symbols, even though definitions may be given somewhere in text. It seems probable to reviewer that many of the equations might be, and perhaps would have to be, simplified for practical use. In absence of experimental data, equations will probably be of value as guide to aileron designer. C. W. Smith, USA

4720. Spreemann, K. P., and Davenport, E. E., Investigation of the aerodynamic characteristics of a combination jet-flap and deflected-slipstream configuration at zero and low forward speeds, NASA TN D-363, 72 pp., May 1960.

An investigation of the aerodynamic characteristics of a semispan wing equipped with a 38.5-percent-chord sliding flap partially immersed in the slipstream of two propellers has been conducted. A jet of air was ejected over the knee of the flap through a momentum range from zero to about 1.0. This investigation was made to provide data on the combined effects of a jet-flap and a flap-deflected slipstream at zero and low forward speeds. Pressure distributions near the wing leading edge behind the inboard propeller for conditions out of ground proximity and within ground proximity were obtained. From authors' summary

4721. Andrews, D. R., Dee, F. W., and Waters, D., Flight measurements of the drag of an aircraft fitted with a rear fuselage fairing designed to reduce the transonic drag, Aero. Res. Counc. Lond. Curr. Pap. 459, 19 pp., 1959.

Tests have been made to determine what reduction in drag could be achieved by fitting a fairing to the rear fuselage of a Hawker Hunter aircraft. This fairing was designed to control the shock wave movements in the wing body junction and so reduce the transonic drag rise. Area distributions at $M = 1.08$ were also improved to some extent.

Comparison of the results before and after modification showed that the fairing had delayed the onset of the transonic drag rise by about 0.015 in Mach number at $C_L = 0.1$ and that the magnitude of the drag rise itself had been reduced by about 0.007 in C_D at $M = 1.00$. Beyond $M = 1.00$ this gain decreased progressively, disappearing entirely at $M = 1.17$. It is noteworthy that these gains were achieved for no increase in the subsonic drag and for no change in the handling characteristics of the aircraft.

From authors' summary

4722. Smith, A. G., The full-scale air drag of some flying-boat seaplanes, Aero. Res. Counc. Lond. Rep. Mem. 3082, 56 pp., 1959.

Paper presents an analysis of measured drag and lift of various British seaplanes dating from the late 1930's to 1950. Characteristics improve with successive designs culminating in the performance of the "Princess," which had a maximum lift-drag ratio of 19. Further improvements are suggested which could add to performance. W. F. Davis, USA

4723. Castles, W., Jr., Durham, H. L., Jr., and Kevorkian, J., Normal component of induced velocity for entire field of a uniformly loaded lifting rotor with highly swept wake as determined by electromagnetic analog, NASA TR R-41, 23 pp., 1959.

See AMR **11**(1958), Rev. 5131.

4724. Heaslet, M. A., and Fuller, F. B., Drag minimization for wings and bodies in supersonic flow, NACA Rep. 1385, 18 pp., 1958.

See AMR **11**(1958), Rev. 3156.

4725. Trescot, C. D., Jr., Effect of streamline contouring in the wing-fuselage juncture in combination with the supersonic area rule on a sweptback-wing-fuselage configuration of high fineness ratio, NASA TN D-387, 19 pp., May 1960.

An investigation has been conducted in the Langley transonic blowdown tunnel at Mach numbers from about 0.67 to about 1.32 to compare two methods for reducing the pressure drag for a high-fineness-ratio sweptback-wing-body combination at a Mach number of 1.3. One configuration was axisymmetrically indented according to the principles of the supersonic area rule and the other configuration employed the streamline concept of shaping the wing-fuselage juncture with the same longitudinal area development as that of the supersonic area-rule configuration.

From author's summary

4726. Brown, B. P., Johnson, H. I., and Mungall, R. G., Simulator motion effects on a pilot's ability to perform a precise longitudinal flying task, NASA TN D-367, 10 pp., May 1960.

Tests have been made on a moving and a fixed simulator to determine the effects motion cues have on pilot's ability to execute control. Quantitative measurements were made with two widely separated stick-force gradients and over a very wide range of longitudinal stability conditions.

From authors' summary

4727. Crane, H. L., A manual frequency sweep technique for the measurement of airplane frequency response, NASA TN D-375, 18 pp., Apr. 1960.

A trial application of a manual frequency sweep technique for the measurement of longitudinal frequency-response characteristics produced satisfactory results except at the airplane short-period resonant frequency. The level of the input power content was found to be high except at and below the airplane short-period resonant frequency for values of frequency up to 20 radians per second. From author's summary

4728. Fisher, L. R., Experimental determination of the effects of frequency and amplitude of oscillation on the roll-stability derivatives for a 60° delta-wing airplane model, NASA TN D-232, 49 pp., Mar. 1960.

An experimental investigation was made at low speeds to determine the effects of oscillation in roll on the roll-stability derivatives for a 60° delta-wing airplane model. Rolling and yawing moments due to both rolling velocity and rolling acceleration were found to be highly dependent on frequency at angles of attack higher than 16°. The oscillatory derivatives were much different at these high angles from the same derivatives measured by steady-state rolling flow tests. Some stability calculations revealed that inclusion of the acceleration derivatives in the equations of motion caused significant changes in the period and damping for a representative airplane.

From author's summary

4729. Brown, A. E., and Schy, A. A., Analysis of the dynamic lateral stability of a delta-wing airplane with frequency-dependent stability derivatives, NASA TN D-113, 44 pp., Nov. 1959.

Available experimental data had shown large frequency and amplitude effects on the lateral stability derivatives of a model of a subsonic 60° delta-wing aircraft at medium and high angles of attack. These data are used to compute frequency response characteristics and time histories of rolling velocities and sideslip in response to step inputs of rolling and yawing moments. For comparison, calculations are also made with the values of the derivatives taken as constant at their steady-state values and at their values at the Dutch Roll frequency ($wb/2V = 0.087$).

The results show that the frequency effects of the stability derivatives on the computer time-histories can be considerable and amplitude effects are also important.

A. D. Young, England

4730. Bramwell, A. R. S., Longitudinal stability and control of the single-rotor helicopter, Aero. Res. Counc. Lond. Rep. Mem. 3104, 60 pp., 1959.

The equations of motion of the helicopter are presented and reduced to nondimensional form. The force and moment derivatives for the single-rotor helicopter (including tailplane if required) are given as simple formulas or in the form of charts. Comparisons are made with wind-tunnel and flight tests where possible and agreement is generally quite good.

In the development of the theory, static and maneuver stabilities are introduced in a manner analogous to fixed-wing aircraft practice. It is shown that the static stability of the helicopter is proportional to the coefficient E in the stability quartic while the maneuvering qualities are represented by coefficient C. The NACA "divergence requirement" is expressed in terms of the "short-period" motion.

Calculations show that the poor damping in pitch of the single-rotor helicopter without a tailplane results in poor maneuvering qualities, i.e., considerable time taken to reach steady acceleration following a control movement, but that the fitting of even a small tailplane provides a great improvement in stability and control.

Report was written in 1957 and just published. Major advancements in this field have been made since 1957 and therefore much of the material has already appeared in published works.

L. Goland, USA

4731. Yff, J., The influence of non-stationary stability derivatives on the snaking motion at high subsonic speed (in English), Nat. LuchtLab. Amsterdam Rap. TR F. 208, 23 pp., Nov. 1957.

The influence of stability derivatives due to sideslip acceleration and yawing acceleration on lateral stability, rolling neglected, is investigated. Numerical calculations performed for two particular cases show that only the yawing moment derivative due to sideslip acceleration has an appreciable effect on the damping of the lateral oscillations. For tailplane designs of aspect ratio below 2 this effect is favorable and increases with Mach number. For higher aspect ratios the effect of this nonstationary derivative is opposite and a reduction of damping of the lateral oscillations occurs.

W. Fiszdon, Poland

4732. Gustafson, F. B., and Tapscott, R. J., Methods for obtaining desired helicopter stability characteristics and procedures for stability predictions, NACA Rep. 1350, 11 pp., 1958.

See AMR **11** (1958), Rev. 253.

4733. Chaplin, H. R., A preliminary design technique for annular-jet ground-effect machines (Gem's), David W. Taylor Mod. Basin Rep. 1371, Aero Rep. 966, 13 pp., Sept. 1959.

This paper provides mathematical formulas and curves sufficient to describe an annular-jet ground-cushion vehicle and its hovering performance. The mathematical approach consists of a "mathematical model" incorporating all of the significant descriptive dimensions of the vehicle. In addition, several efficiency factors have been introduced to account for effects to be encountered in operation. Additional supporting equations are provided to fully describe the physical conditions of the vehicle in hovering. This performance description method also allows comparisons to be made of different vehicle designs.

From author's summary by C. E. Carver, Jr., USA

4734. Chaplin, H. R., Theory of the annular nozzle in proximity to the ground, David W. Taylor Mod. Basin Rep. 1373, Aero Rep. 923, 41 pp., July 1957.

A simple theory is presented for the effect of ground proximity on the force acting on a stationary body containing a downward-blowing annular nozzle around the periphery of its base. The results are found to be in agreement with experimental data.

From author's summary by C. E. Carver, Jr., USA

Vibration and Wave Motion in Fluids

(See also Revs. 4390, 4415, 4522, 4561, 4643, 4657, 4670, 4729, 4797, 4826, 4845, 4862, 4871, 4917, 4919, 4924, 4939)

4735. Chang, C. T., Dynamic instability of accelerated fluids, *Physics of Fluids* **2**, 6, 656–663, Nov./Dec. 1959.

The nonlinear growth of waves at the surface of an inviscid fluid filling the lower half-space and subjected to a downward acceleration is studied by means of a Taylor expansion in the initial wave height. Surface tension is taken into account and is shown to have a stabilizing influence. Results are carried out to the third-order approximation for an initially sinusoidal wave, which is shown to develop higher harmonics with a resulting narrowing of the crest and broadening of the trough.

Comparison is made with an earlier linearized treatment where the existence of a cutoff wave number was demonstrated. The present higher-order theory predicts oscillatory growth of waves with wave numbers greater than this cutoff value, a result which has been indicated by previous experiments cited by the author.

W. P. Graebel, USA

4736. Iordanskii, S. V., The asymptotics of an axially symmetric diverging wave in a heavy fluid, *Soviet Phys.-Doklady* **4**, 2, 284–287, Oct. 1959. (Translation of *Dokladl Akad. Nauk SSSR (N.S.)* **125**, 6, 1211–1214, Mar./Apr. 1959 by Amer. Inst. Phys., Inc., New York, N. Y.)

The axisymmetric equivalent of the solitary wave is obtained by a successive-approximations solution for a constant depth much smaller than the "wavelength." Author states that the same method could be extended to waves in fluid of gradually varying depth.

L. R. Mack, USA

4737. Chappelear, J. E., Wave forces on groups of vertical cylinders, *J. Geophys. Res.* **64**, 2, 199–208, Feb. 1959.

Drag and inertia coefficients for a single circular cylinder placed in a stream of velocity u are assumed to be known experimentally and to be constant. Groups of cylinders of different geometrical configuration are considered. It is assumed that the forces on any one circular cylinder in a group can be obtained by making use of the experimentally determined drag and inertia coefficients for one cylinder and by correcting u at the cylinder considered, for the presence of all the other cylinders. Correction factors for different cylinders in various configurations are listed.

Reviewer cannot quite agree with the author's statement that: "Even in the case of small waves on a single cylinder the calculations are so complicated and the theory in such an unreliable state that no conclusions could be drawn." Moreover, any wave theory will bring out the mutual wave action of the different cylinders in a configuration.' In particular the analysis will show the characteristic interference effects on a cylinder which lies within the wave pattern left by another cylinder.

J. K. Lunde, Norway

4738. Meyer, R. E., A Liouville theorem for shallow-water waves, Brown Univ., Div. Appl. Math TR21 (Contract Nonr 562(07) (Nr-062-179)), 38 pp., Oct. 1959.

It is shown that the hyperbolic differential equations governing plane shallow-water waves under gravity do not permit nontrivial solutions free of regions where the pattern of characteristic lines in the space-time plane shows envelopes or folds (limit lines). In spite of the weak coherence properties of the solution functions—the values of which when given on a curve segment determine a continuation of the solution, at most, in a finite region—any continuation of a locally given solution will meet a singularity if continued far enough. Theorem is proved by methods used in gas dynamics.

To reviewer's regret paper contains no discussion on necessary and sufficient conditions regarding the differential equations to allow this theorem. Could the antithesis, i.e. the existence of an everywhere nonsingular, nontrivial solution, perhaps be contradicted by the classical Liouville theorem, applied to a conformal mapping of suitable variables in the space-time plane into the plane of some characteristic variables?

K. Eggers, Germany

4739. Grigorash, Z. K., Waves on the surface of a liquid, developing as the result of small eruptive underwater impulses (in Russian), *Trudī Morsk. Gidrofiz. In-ta Akad. Nauk SSSR* **11**, 18–27, 1957; *Ref. Zh. Mekh.* no. 2, 1959, Rev. 1426.

This is an experimental study of the propagation of surface waves forming as the result of underwater explosions of spheres filled with a detonating mixture. The shells were of two capacities: 8 – 5 liters and diameter 25 cm and 17 liters and diameter 32 cm. The experiments were carried out in a natural reservoir, with a depth of 1.15 to 1.20 m, the surface of the reservoir being undisturbed until the explosions took place. The detonations of the shells of smaller diameter were carried out at depths of 22.5, 32.5, 42.5 and 52.5 cm, and of the larger at depths of 26, 36 and 46 cm. The system of waves produced was photographed from the shore with a hand-operated cinecamera held at water level. The photographic rate was 24 to 32 frames a minute. The experimental material obtained is given in the form of a number of curves. A comparison is made between the experimental results of changes in the waves' profiles and the author's calculations, carried out by the methods of approximate integration (Simpson's method and the method of mechanical quadrature) by Terazawa's formulas [K. Terazawa, *Proc. Roy. Soc. Lond.* (*A*) **92**, p. 57, 1915]. As the result of the investigations the author puts forward the following conclusions: (1) The character of the waves formed as the result of the explosion agrees in general features with the theoretical deductions obtained from the solution of problems of the Cushi-Poisson type. (2) The height of the crest of the first annular wave h above the quiet surface, created by the underwater explosion, is the largest of all the waves and conforms to relations having the form of

$$h = Ar^{-3/2} z^{-4/3} v^{4/3}$$

where r is the distance covered by the wave from the point of emergence of the explosion in a horizontal direction, z the depth of explosion, v the volume of the explosive mixture by hydrogen with air was found to be approximately 213 in the CGS system. (3) The length of the wave increases with increase of distance from the point of explosion. This increase, it can be supposed, proceeds in accordance with the stepped relation of the form

$$\lambda = A_1 r^n$$

For large shells n is approximately equal to 1.5–1.9, for small shells the value of n fluctuates between 1 to 1.5. (4) The velocity of propagation of the waves increases with the distance; it is largest at a given distance for the first wave; the velocities of all the successive waves decrease with increase of the serial number of the wave (for the same given distance).

P. P. Koryavov

Courtesy Referativnyi Zhurnal, USSR

4740. Sarpkaya, T., Oscillatory gravity waves in flowing water, *Trans. Amer. Soc. Civ. Engrs.* **122**, Pap. 2873, 23 pp., 1957.

Paper gives the results of very accurate tests on the characteristics of ascending gravity waves of stable form in flowing water. Author states that "for a given flow there is only one neutrally stable wave," all other waves showing either an exponential damping or an amplification during their propagation. The wave celerity (measured relative to the mean velocity of flow) has been found to be as much as 10% smaller than the theoretical value for still water. Besides a dimensional analysis, paper makes no pretense of adding to the theoretical understanding of the subject.

H. Lundgren, Denmark

4741. Holsters, H., Calculation of a simple sinusoidal tide propagating in two dimensions (in French), *Ann. Trav. Publ. Belgique* no. 2, 129–141, Apr. 1959.

Author presents method for calculation of effects of project Delta, involving the closure of some sea inlets at mouth of Western Scheldt River, on mean tide regime. Tide at sea is assumed unchanged at or beyond a certain line far enough from source of perturbation. Method will be used for tide hindcast under present conditions, as a first step to check its accuracy for forecast under modified conditions. Fundamental energy and continuity equations are written assuming two-dimensional variation of velocity in plan. Friction term is linearized according to Lorenz procedure of assuming a constant computed with constant velocity producing same work as actual velocity during a complete tide. Coriolis force is taken into consideration only for its horizontal components. Tide elevation and velocities are considered simple sinusoidal and given by real parts of three complex functions or their conjugates. A system of three equations is given on the complex values of tide and velocity components and another system on the conjugate values. In general, these equations cannot be integrated except by finite differences.

Author proposes a network of equal square meshes representing the geographical limits of problem. Equations are rewritten for a normal mesh point (i.e. for equal arms cross), for a point on shore, and for a point on tidal inlet (here velocity must be related to tide by cubature). A system of nonlinear equations results, which may be solved by iteration or by successive approximations. Method contemplates the use of normal desk calculating machines, but electrical analogies may also be utilized. Uniqueness of solution is next discussed by author. Paper ends with some notes on derivation of equations used in method. Author leaves for further papers a presentation of actual numerical calculations applied to project.

A. Balloffet, USA

4742. Ryazanov, E. V., Exact solutions for the propagation of explosion waves in a gravitating gas with zero temperature gradient, *Soviet Phys.-Doklady* **4**, 3, 537–540, Dec. 1959. (Translation of *Dokladf Akad. Nauk SSSR (N.S.)* **126**, 5, 955–958, May/June 1959 by Amer. Inst. Phys., Inc., New York, N. Y.)

4743. McCarty, J. L., and Stephens, D. G., Investigation of the natural frequencies of fluids in spherical and cylindrical tanks, NASA TN D-252, 20 pp., May 1960.

Several propellant-tank configurations applicable to missile designs were oscillated to study the natural frequencies of a contained fluid over a range of tank sizes and fluid depths and to develop expressions relating these natural fluid frequencies to certain physical parameters. The configurations included spheres and circular cylinders that could be oriented with respect to the direction of oscillation. Nondimensional parameters, based upon the results of these tests, appear to be valid for the prediction of the natural frequencies of fluids in all tanks of a given configuration regardless of size.

From authors' summary

4744. Miller, R. W., Hydrodynamic impact-loads investigation of chine-immersed 0° dead-rise configurations having longitudinal curvature, with an appended bibliography of Langley impact basin hydrodynamic publications, NASA TN D-207, 38 pp., Feb. 1960.

Impact-load data are presented for two narrow-beam configurations: one having the forward half curved upward, the other having the same curvature over the rear half. Impacts were made at fixed trim in smooth water at beam loading coefficients of about 18, 29, and 36 and over a range of landing-approach conditions. The results indicated behavior similar to other chine-immersed models at positive trims with some load alleviation by the curved stern at 0° trim.

Inasmuch as this paper is the last one from the Langley impact basin, which is now deactivated, a bibliography is included of all other publications on hydrodynamic investigations from this basin since its inception. From author's summary

4745. Borg, S. F., Three-dimensional wedge impact on a compressible fluid, *J. Appl. Phys.* **31**, 2, 438-439 (Letters to the Editor), Feb. 1960.

4746. Engel, Olive G., Pits in metals caused by collision with liquid drops and rigid steel spheres, *J. Res., Nat. Bur. Stands.* **64** A (*Phys. and Chem.*), 1, 61-72, Jan.-Feb. 1960.

A pit-depth-versus-velocity equation developed earlier was tested further with experimental data obtained using target plates of electrolytic tough pitch copper, 1100-O aluminum, and 2024-O aluminum, the static strength properties of which were measured by testing tensile specimens. The projectiles used to produce the pits were mercury drops, water drops, and steel spheres. It was found that the numerical constants in the equation for projectiles that flow during and as a result of the collision are different from those for projectiles that do not flow (hardened steel spheres). Curves calculated using the equation were found to be in acceptable agreement with experimental pit-depth-versus-velocity data for collisions of the indicated projectiles with target plates of the three metals used with the exception of the case of steel-sphere impingement against 2024-O aluminum alloy. In this case work-hardening of the target metal seems to foster a mode of pit formation that was not considered in the development of the pit-depth-versus-velocity equation.

From author's summary

4747. Sarpkaya, T., The effect of unsteadiness on hydrodynamic resistances and on mass oscillations in surge tanks, *Trans. Engng. Inst. Canada* **3**, 3, 96-99, Nov. 1959.

The basic question in the prediction of transients involving hydrodynamic or aerodynamic phenomena is the effect of unsteadiness on the fluid friction. This paper presents the analysis of the transient motion in a simple surge tank taking into consideration the effect of change of boundary-shear stress in unsteady turbulent flow. The nonlinear differential equation of motion is solved by means of an analog computer and by stepwise integration. It is found that as much as twenty per cent error can be made in the computation of first maximum and minimum oscillations if the effects of unsteadiness on friction head loss are disregarded. Also the period of oscillation is noticeably different for constant and variable friction coefficients. From author's summary

4748. Filatov, A. N., On the dynamic action of a liquid on a tank during arbitrary longitudinal acceleration (in Russian), *Trudi In-ta Mat. i Mekh. Akad. Nauk UzSSR* no. 21, 107-111, 1957; *Ref. Zh. Mekh.* no. 2, 1959, Rev. 1433.

A study is made of the potential linearized wave motion of a heavy liquid of small depth, partially filling a cylindrical cistern, moving with an acceleration of $a(t)$ in the direction of its own axis of symmetry. The author, disregarding the motion of the liquid in a lateral direction and by averaging the arbitrary free surfaces and directions of the cistern's motion, seeks the resolution of the free surface of the liquid in the form of a Fourier series and obtains the following expression

$$\eta(x, t) = -\frac{ax}{g} + \sum_{n=0}^{\infty} \left\{ a_n \cos ck_n t + \frac{b_n}{ck_n} \sin ck_n t + (-1)^n \frac{2}{c \lg k_n^3} \int_0^t a(\tau) \sin ck_n (t-\tau)\, d\tau \right\} \sin k_n r$$

Here $k_n = \pi(2n+1)/1$, $c = \sqrt{gb}$ is the length of the cistern, b the reduced depth of liquid in it, a_n, b_n constants depending on the initial conditions. The pressure is computed of the oscillating liquid on the cistern and a calculation made for the special case—a linear acceleration ($a = \beta - \alpha t$), for which the maximum pressure of the liquid on the cistern is equal to

$$Q_{max} = \frac{P c \beta^2}{2e\alpha g} \left(\frac{\beta}{\alpha} \leqslant \frac{2e}{c} \right)$$

where P is the weight of the poured-in liquid.

S. V. Zhak

Courtesy Referativnyi Zhurnal, USSR

4749. Blaser, H., Dynamical problems of hydraulically actuated piston drives, starting and braking process, piston vibrations, water hammer (in German), Von Roll Mitteilungen **16**, 1/4, 61 pp., Jan./ Dec. 1957.

Dynamic behavior of hydraulic pistons and plungers under the action of liquid pressure is investigated, in particular in hydraulic presses, in order to clarify the disturbances due to jerky piston motion, piston vibrations, and water hammer. First, piston friction is discussed, and formulas are derived based on viscous (Newtonian) friction due to the oil film between the piston and cylinder, and on dry (Coulomb's) friction; flow resistance in the piping is also discussed and formulas are given. Equations of piston motion on sudden application of liquid pressure are derived, assuming no-load condition, incompressible liquid and nonelastic cylinder walls, in the presence either of Newtonian or of Coulomb's friction. Main portion of paper, pp. 29-55, deals with the dynamical behavior of piston and liquid column, taking the compressibility of liquid, and elasticity of cylinder wall and piping, into consideration. This treatment is carried out with a graphical method, developed in previous researches on water-hammer phenomena in hydraulic power plants, and on fuel-injection phenomena in diesel engines, which are listed as references.

The concepts and procedures of this method are explained for an assumed case, in which the piston, moving at a certain velocity, comes to a sudden stop at the end of its stroke. The ensuing fluctuation of pressure, and variation of rate of flow in the piping, are represented in a diagram giving the pressure versus rate of flow; the corresponding pressure-versus-time diagram is also given. Other characteristic phenomena of pressure and piston oscillations are investigated, such as: Motion of piston on sudden opening of the valve between the pressure liquid accumulator and the cylinder, assuming various simplified conditions; pressure fluctuations in the cylinder, initially at high pressure at the end of its power stroke, on sudden release of pressure by opening the discharge valve; pressure and piston oscillations at sudden closure of the discharge valve during the idling, return stroke of the piston.

Differential equations for some of the above phenomena are also derived, substituting step functions for boundary conditions which cannot be expressed as explicit functions. A number of photographs of hydraulic presses manufactured by the Louis De-

Roll Ironworks, Ltd., Gerlafingen, Switzerland, are included. The above listed examples are fully explained and illustrated, giving not only an insight into the interplay of forces and flow velocities in the given systems under given conditions, but teaching the graphical method for solving other dynamic phenomena in which elastic forces play a part. K. J. DeJuhasz, USA

4750. Mamontov, M. A., Variants of the basic relations for the flow of a gas in the space beyond the piston (in Russian), *Trudi Tul'sk. Mekh. In-ta* no. 8, 96–105, 1958; *Ref. Zh. Mekh.* no. 2, 1959, Rev. 1216.

Different forms of equations in terms of Euler and Lagrange variables are put forward for single-dimension unsteady flows of a gas in a tube. No examples of the calculation are given in the paper. O. S. Ryzhov

Courtesy Referativnyi Zhurnal, USSR

4751. Nagao, F., Shimamoto, Y., and Mizuyama, Y., Study on exhaust pipes with an ejector, *Bull. JSME* **2,** 7, 405–410, Aug. 1959.

Paper reports results of experimental investigation of scavenging effect of the exhaust of one cylinder on remaining cylinders of an engine. Simplified model of the manifold consists of a mixing pipe joining the outlets of a cylinder exhaust pipe and a dummy exhaust pipe. Experimental results show the existence of an optimum length of the mixing pipe and an optimum area ratio of mixing and exhaust pipes, both variable with the pressure conditions. A one-dimensional isentropic calculation yields fair agreement with experimental results. No reference is made to similar work performed some years ago by F. J. Wallace and by F. K. Bannister and G. F. Mucklor in England.

J. R. Moszynski, USA

4752. Nagao, F., and Shimamoto, Y., Production of negative pressure by an exhaust pipe with stepped or conical open end, *Bull. JSME* **2,** 7, 411–416, Aug. 1959.

Paper reports results of theoretical and experimental investigation of conical and stepped open ends of exhaust pipes on cylinder scavenging. The flow in the pipe is assumed isentropic and one-dimensional; the calculated pressures show fair agreement with experiment. The existence of an optimum area ratio for a stepped pipe is demonstrated. J. R. Moszynski, USA

4753. Gosi, S., Investigation of the operation of the "Ganz-Jendrassik" diesel injector system (in Hungarian), *Jarmuvek Mezogazdasagi Gepek* **6,** 2, 44–53, Feb. 1959.

The study deals with the Jendrassik-type, spring-driven diesel fuel injector. Starting with the equations for hydraulic oscillations, author develops expressions for the motion of the injector and for the forward-running pressure wave in the hydraulic system. The pressure-time curves are calculated after stopping of the injector piston. Finally, the analytical results are compared with experimental curves. T. P. Torda, USA

Fluid Machinery

(See also Revs. 4631, 4652, 4658, 4659, 4665, 4733, 4778, 4925, 4956)

4754. Grewe, K. H., Comparison of experimental and theoretical pressure distributions in two-dimensional cascades at high subsonic velocities (in German), *Forsch. Geb. Ing.-Wes.* **25,** 1, 1–16, 1959.

The first systematic cascade measurements are presented which were carried out in the recently established High-Speed Variable-Density Wind Tunnel at the Deutsche Forschungsanstalt für Luftfahrt (DFL). Pressure distribution measurements were made with cascades of NACA 0010 and 8410 profiles of varying solidity, blade angles and angles of inflow in a wide range of compressor and turbine cascades. The inlet Reynolds number was held constant, while the inlet Mach number was increased up to the blocking speed. By means of integration of the pressure distribution along the profile shape blade-force coefficients and outlet angles are also given.

Below the critical Mach number, at which the local Mach number reaches unity, the pressure measurements are in quite good agreement with theoretical predictions using the Prandtl-Glauert approximation for subsonic flow [AMR **12**(1959), Rev. 3467]. Above this limit the apparent shock waves strongly influence the pressure distributions. N. K. H. Scholz, Germany

4755. Schlichting, H., Application of boundary-layer theory in turbomachinery, *ASME Trans.* **81**D (*J. Basic Engng.*), 4, 543–551, Dec. 1959.

A general survey has been given of methods of calculating the flow of a viscous and incompressible fluid through two-dimensional cascades, as worked out in the Institute of Fluid Mechanics of the Technical University of Braunschweig in recent years.

The method permits theoretical calculation of all aerodynamic coefficients for two-dimensional cascades, including loss coefficients from boundary-layer theory, in good agreement with experiments. Special attention is given to optimum cascades, i.e. to cascades which give a maximum of deflection at a minimum loss coefficient. For optimum cascades the flow is found to be partly separated in most cases. The theory also gives the influence of Reynolds number on the loss coefficients of cascades provided that the region of separated flow is small. Finally, the results of cascade theory are applied to the calculation of the characteristic curves of a single-stage axial-flow compressor.

From author's summary by L. C. Woods, England

4756. Kamimoto, G., Matsuoka, Y., and Shirai, H., Effects of fluid viscosity on the flow in the impeller of centrifugal type hydraulic machinery, *Bull. JSME* **2,** 8, 624–629, Nov. 1959.

This paper deals with effects of fluid viscosity on the performance and pressure distribution along vane surfaces of impeller of centrifugal-type hydraulic machinery. An impeller was rotated in the water whose viscosity was changed by adding glycerin. Head, flow quantity and pressure distribution along vane surface were measured. Head coefficient and efficiency as well as the flow-rate coefficient at maximum efficiency decrease with increasing viscosity of the fluid. Also, the more the viscosity increases the more the surface pressure decreases.

Author says that it seems possible to theoretically develop the effects of viscosity by taking into consideration the displacement thickness of boundary layer along surfaces and shrouds.

S. Otsuka, Japan

4757. Kamimoto, G., and Matsuoka, Y., Theory of centrifugal type impeller with vanes of arbitrary form, *Bull. JSME* **2,** 8, 630–637, Nov. 1959.

This paper deals with a theory about impeller of centrifugal type hydraulic machinery with vanes of arbitrary shape. Theory contains a method of conformal mapping based on a mapping function which maps logarithmic spiral into a unit circle, and Fourier's series is added for representing arbitrary shape of vanes. Calculation results agree fairly well with experimental results. Reviewer supposes that this method is suitable for impeller vane of small solidity. S. Otsuka, Japan

4758. Abe, S., Theory of the impeller of multiblade centrifugal fans, *Rep. Inst. High Speed Mech., Tohoku Univ.* **10,** 149–176, 1959.

Incompressible flow is studied through an impeller with parallel walls and short, thin blades, the shape of which does not deviate much from a logarithmic spiral. The impeller is conformally mapped into a closed curve which deviates slightly from a unit circle. The flow is composed of a source flow and a vortex flow, each represented by a doublet. Using the fact that the difference is small between the shape of the blades and a logarithmic spiral, author derives approximate formulas for impeller characteristics such as theoretical head, velocity distribution along a blade and mass flow giving shockless entrance. The velocity distribution along the blades of two common types of impellers is calculated showing poor velocity distributions.

Author then derives a method for calculating the blade shape from a prescribed favorable pressure distribution and presents two numerical examples. No correlation with test data is shown.

O. Soderberg, Sweden

4759. Sentek, J., Similarity in gas compression of radial compressors in case of different adiabatic exponents (in German), *Öst. Ingenieur Z.* **2,** 6, 226–231, June 1959.

Author develops similarity conditions for the compression of gases of different adiabatic exponents. The method is based on the assumption of polytropic compressions and the negligible effects of changes in (high) Reynolds numbers. It applies to uncooled turbocompressors. The method permits testing with air instead of design gases, modification of existing designs for other gases and model testing. E. J. McBride, USA

4760. Acton, O., On the determination of velocity triangles and pitch angles of rotor blades in an axial compressor (in Italian), *Aerotecnica* **39,** 3, 120–125, June 1959.

Changes in velocity vector diagrams and nondimensional coefficients are discussed for the case of a constant-speed compressor stage with flow rate regulation through rotor blade pitch control. Analytical relations are developed for the direct calculation of the required pitch for each operating condition.

From author's summary by J. V. Foa, USA

4761. Shivers, J. P., High-tip-speed static-thrust tests of a rotor having NACA $63_{(215)}$ A018 airfoil sections with and without vortex generators installed, NASA TN D-376, 21 pp., May 1960.

An investigation has been made on a rotor having NACA $63_{(215)}$ A018 airfoil sections with and without vortex generators installed to determine the maximum mean lift coefficients at low tip Mach numbers and the compressibility effects at high tip Mach numbers. Data are presented for blade-tip Mach numbers from 0.27 to 0.76 and corresponding tip Reynolds numbers from 1.67×10^6 to 4.59×10^6. From author's summary

4762. Jewel, J. W., Jr., Compressibility effects on the hovering performance of a two-blade 10-foot-diameter helicopter rotor operating at tip Mach numbers up to 0.98, NASA TN D-245, 28 pp., Apr. 1960.

The rotor blades have an NACA 0012 airfoil section, 2/1 taper ratio, −12° of twist, and a solidity of about 0.10. Performance curves are presented for tip Mach numbers from 0.09 to 0.98 and disk loadings as high as 22 pounds per square foot. Induced velocities 15 and 45% of the radius beneath the rotor are given for the maximum disk loads for a representative range of tip Mach numbers. Sound-pressure levels measured at a point about 30 feet from the center of rotation and on a radial line inclined 5° below the plane of rotation are included for all Mach numbers above 0.45 covered in the tests. From author's summary

4763. Stepka, F. S., and Cochran, R. P., Experimental and analytical investigation of heat-transfer characteristics of a return-flow air-cooled turbine rotor blade, NASA TN D-202, 21 pp., Dec. 1959.

Results are presented of study of the return-flow air-cooled turbine rotor blade intended for use in a closed-circuit gaseous-coolant system. In such a system, hydrogen or helium provides more effective cooling than air when high turbine inlet temperature is used. The cooling performance of a typical blade configuration was determined experimentally and is compared with predicted performance. Effective cooling to allowable blade surface temperature was maintained with coolant flow of 0.01 to 0.04 lb per sec per blade (approximately 0.6 to 2% total gas flow) with coolant inlet at 230 to 445 F. The manifolding and sealing of coolant passages are believed to be novel. S. L. Soo, USA

Flow and Flight Test Techniques and Measurements

(See also Revs. 4629, 4653, 4683, 4722, 4763, 4806, 4863, 4915)

4764. Boetticher, C. K., Ultrasonic velocity and volume flow measurement in liquids (in German), ETH Zurich Prom. 2795, 40 pp., 1958.

After a detailed review of ultrasonic flowmeter methods, author describes his own new method. The measurement is taken along an oblique path across the channel and the time of flight of acoustic pulses is different in the two opposite directions due to flow velocity. The time of flight is measured as a pulse repetition rate, consequently there is a difference in the pulse frequencies for the two opposite directions. The difference frequency thus obtained is a direct measure of the component of flow velocity in the direction of propagation integrated along the path. The average accuracy obtained is of the order of ±0.4%.

L. S. G. Kovasznay, USA

4765. Landstra, J. A., Quarter-circle orifices, *Trans. Inst. Chem. Engrs.* **38,** 1, 26–32, Feb. 1960.

Experiments have been made which indicate that quarter-circle orifices in differential-pressure primary-flow devices can be used for measuring liquid flow rates at Reynolds numbers smaller than 100,000, *i.e.* for relatively viscous liquids with moderate velocities.

The manufacturing procedure and the limitations of the use of the orifices are discussed. The Reynolds number limits have been found to differ from those published elsewhere. It has been demonstrated that all cases of flow measurement at low Reynolds numbers can be covered with a restricted number of plate sizes.

Some measurements are more extensively described in an appendix. From author's summary

4766. Takeda, R., Research on current meters (2nd report), *Bull. JSME* **2,** 8, 602–608, Nov. 1959.

The author develops a vane-type anemometer for which the rpm of the meter varies as the cosine of the angle between the meter axis and the flow direction. He succeeds in constructing such a device by using a six-blade runner, three having circular and three having flat-plate profiles. J. Laufer, USA

4767. Vagas, I., Flow measurement by means of dye surges (in Hungarian), *Hidrológiai Közlöny* **39,** 3, 205–207, June 1959.

4768. Kuchay, S. A., The manometer error caused by small leaks in the casing of a satellite, NASA TT F-14, 7 pp., Apr. 1960.

On the basis of assumptions concerning the source of leaks, the gaseous surroundings, and the laws pertaining to the scattering of molecules, a study is made of manometer errors caused by leaks in the casing of a satellite. The results permit formulation of

qualitative requirements for sealing satellites to avoid excessive error. From author's summary

4769. Stuart, J. W., Jr., The pitot and static tubes—condensed sources of general fundamentals and applications, *J. Aero/Space Sci.* **27,** 2, 136–137 (Readers' Forum), Feb. 1960.

This note is a condensed collection of papers which fill the void for the subject of pitot and static tubes, their origin, principles, theory, evolution, performance, and modern modifications and applications. From author's summary

4770. Cannon, M. R., Manning, R. E., and Bell, J. D., The kinetic energy correction and a new viscometer, *Anal. Chem.* **32,** 3, 355–358, Mar. 1960.

Experiments performed by the authors on capillary viscometers selected to magnify the kinetic energy correction term show that this correction is a function of the Reynolds number and varies inversely as the square of the efflux time rather than the first power of this time as it is usually written. A patented modification of the Ubbelohde viscometer (Cannon-Ubbelohde) is described for which the kinetic energy correction is negligible for viscosities as low as 0.4 cs. Two typographical errors are apparent in Eq. [5]. W. J. Moreland, USA

4771. Al'tshul', A. D., On the theory of viscosimeters for the determination of relative viscosity, *Measurement Techniques* no. 6, 707–710, Mar. 1960. (Translation of *Izmeritel' naia Tekhnika, USSR* no. 6, 78–79, Nov./Dec. 1958 by Instrument Society of America, Pittsburgh 22, Pa.)

4772. Axpeitia, G., and Newell, G. F., Theory of oscillation-type viscometers: Part 3, A thin disk; Part 4, A thick disk; Part 5, Disk oscillating between fixed plates (in English), *ZAMP* **9a,** 2, 97–118, July 1958; **10,** 1, 15–34, Jan. 1959; **10,** 2, 160–174, Mar. 1959.

Papers discuss the problem of the free oscillatory motion of a disk suspended in a fluid and supported by a torsion wire. The hydrodynamic model for the thin disk, thick disk and disk between fixed plates takes account of all the linear terms of the Navier-Stokes equations. Authors have succeeded in obtaining accurate and usable formulas relating the viscosity and density of the fluid to the observed logarithmic decrement and frequency of the pseudo-damped harmonic torsional oscillation. Satisfactory agreement is shown to exist between theoretical predictions and some experimental data.

However, this reviewer believes that, until it can be demonstrated that the effects of axial and radial flow, and the secondary motions (swinging and tilting) of the disk are negligible, it cannot be considered established that the disk viscosimeter could be used generally for the determination of absolute viscosity.

Part 1 contains the list of symbols and definitions of terms. The term $\tau\omega_o^2$ is called the spring constant, but this is not compatible with its use in Eq. [1], Part 1. The definitions of Λ and ω are not correct and that for τ contains a misprint. The expression for circular frequency on page 448, Part 1, is greater than unity, which appears incorrect.

W. J. Moreland, USA

4773. Jackson, Mary W., and Czarnecki, K. R., Investigation by schlieren technique of methods of fixing fully turbulent flow on models at supersonic speeds, NASA TN D-242, 16 pp., Apr. 1960.

An investigation was made of the effects of two-dimensional wire and three-dimensional granular roughnesses on transition on a 27° cone at a free-stream Mach number of 2.20 and an angle of attack of 0° over a tunnel Reynolds number range of about 1.0×10^6 to 7.0×10^6. An estimated local unit Reynolds number which indicated first appearance of forward movement of transition from the smooth cone gave a roughness Reynolds number based on roughness height and flow conditions at top of roughness of 600 for the three-dimensional granular roughness. Transitional roughness Reynolds numbers in the vicinity of the roughness location were of the magnitude 4500 to 6500.

From authors' summary

4774. Tanner, L. H., The design and use of interferometers in aerodynamics, Aero. Res. Counc. Lond. Rep. Mem. 3131, 66 pp., 1959.

The paper extends an earlier one on the optics of the Mach-Zehnder interferometer. It gives a practical account of the problems which are encountered in the design and use of interferometers on wind tunnels and shock tubes, and in the analysis and interpretation of interferograms. Topics covered include the design of frame and suspension, mirror mounts and adjustments, the choice of adjustable mirrors and the effects of passing the compensating beam through the tunnel or outside it.

A section on optics gives an account of the range, sensitivity and relative merits of the Mach-Zehnder and Twyman-Green interferometers, and compares the permissible source aperture and duration with those used for schlieren photography.

A section on factors affecting accuracy deals with temperature changes and stress in the windows, convection currents and vibration, side-wall boundary layers, unsteady flow and loss of total pressure through shock waves and in dead-air regions. Some experimental results show that reasonable accuracy may be obtained. A mechanical analyzer is described which performs the computation and plots the pressure distribution along any desired line.

A section on the use of interferograms for qualitative flow visualization shows that they give a very complete picture of the flow, with very little distortion.

Finally the Appendices give descriptions of the interferometer which is used on the 9-in. × 3-in. High-Speed Wind Tunnel at the National Physical Laboratory, and of a larger instrument which is being made. From author's summary

4775. Kresa, K., and Mollo-Christensen, E., A multiple hot-wire array for measurements of downwash integrals, *J. Aero/Space Sci.* **27,** 2, 141–142 (Readers' Forum), Feb. 1960.

4776. Kobashi, Y., Kono, N., and Nishi, T., Improvement of a pressure pickup for the measurements of turbulence characteristics, *J. Aero/Space Sci.* **27,** 2, 149–151 (Readers' Forum), Feb. 1960.

4777. Wood, M. N., and Trebble, W. J. G., Low speed tunnel measurements of the ground effect on a 1/5th scale model of the Swift, Aero. Res. Counc. Lond. Curr. Pap. 458, 54 pp., 1959.

Low-speed tunnel tests have been made on a 1/5th scale model of the four-gun Swift to collect information on the effect of ground on swept-winged aircraft. Lift, drag and pitching moment have been measured with the model in free stream and also at two distances from a ground board, the nearer position of the mean quarter chord point being 0.42 mean chords from the board. Two tailplane positions and various flap configurations have been tested.

Existing theories on ground effect for unswept wings give good estimates of the decrease in induced drag but underestimate the gain in lift-curve slope and overestimate the effect of the ground on the downwash at the tailplane. Slight modifications to the theories are suggested. From authors' summary

4778. Sweet, G. E., Static-stability measurements of a stand-on type helicopter with rigid blades, including a comparison with theory, NASA TN D-189, 50 pp., Feb. 1960.

Results of an investigation in low-speed forward flight are presented. The results include measurements of forces and mo-

ments and static-stability derivatives determined from these measurements. Pitching moments and static-stability derivatives for the isolated rotors, as deduced from the measurements, are compared with rigid-rotor theory.

From author's summary

4779. Kuhn, R. E., and Hayes, W. C., Jr., Wind-tunnel investigation of longitudinal aerodynamic characteristics of three-propeller-driven VTOL configurations in the transition speed range, including effects of ground proximity, NASA TN D-55, 128 pp., Feb. 1960.

The investigation employed a semispan wing model with two propellers arranged so that their slipstreams covered most of the wing semispan. A sliding flap and a Fowler flap were fitted so that the model could be tested as a tilt-wing configuration, a deflected-slipstream configuration, or a combination tilt-wing-deflected-slipstream configuration. Tests were made with a ground board installed below the model and with the ground board removed. Some measurements of the flow field (angularity and dynamic pressure) in the general location of a horizontal tail were made.

Results of the investigation are illustrated by the estimated performance and control characteristics of a hypothetical airplane.

From authors' summary

4780. Landrum, Emma Jean, and Czarnecki, K. R., Pressure distributions and aerodynamic characteristics of several spoiler controls on a 40° sweptback wing at a Mach number of 1.61, NASA TN D-236, 66 pp., Apr. 1960.

An investigation was made at a Mach number of 1.61 and a Reynolds number of 3.6×10^6 to determine the characteristics of a series of five spoiler controls on a 40° sweptback wing having an aspect ratio of 3.1 and a taper ratio of 0.4. Wing angle-of-attack range was −15° to 15°. Incremental pressure distributions due to the spoilers were in good agreement with previous flat-plate results and with the results of tests of spoilers on a trapezoidal wing. The spanwise loadings and integrated lift, bending-moment, and pitching-moment coefficients are also presented.

From authors' summary

4781. Letko, W., Experimental investigation at a Mach number of 3.11 of the lift, drag, and pitching-moment characteristics of five blunt lifting bodies, NASA TN D-226, 13 pp., Apr. 1960.

The Reynolds number of the tests were 16×10^6 per foot. All the bodies tested were statically unstable about the geometric center of the bodies, except one which was neutrally stable. The results indicate that Newtonian theory might be applied for estimating the drag at zero angle of attack and the pitching-moment-curve slope. Indications are, however, that Newtonian considerations would not apply for estimating the normal force of bodies of the type tested at the Mach number of the tests.

From author's summary

4782. Reed, R. D., Vertical-tail loads measured in flight on four airplane configurations at transonic and supersonic speeds, NASA TN D-215, 31 pp., Feb. 1960.

Aerodynamic loads were obtained from the X-5 airplane, an F-100 with a small vertical tail, an F-100 with a large vertical tail, and the X-1E airplane. Effects of sideslip angle, rudder deflection, and Mach number are presented for trim flight at altitudes from 40,000 feet to 70,000 feet and at Mach numbers from 0.70 to 2.08. Comparisons are made with simple theoretical methods of estimating the loads. Also, the total directional stability for each airplane as calculated by use of vertical-tail loads is shown.

From author's summary

4783. Clark, J. P. C., An experimental investigation of a supersonic two-dimensional perforated inlet at a nominal free stream Mach number of 2.5, Univ. Toronto Inst. Aerophys. Rep. 24, 48 pp., Nov. 1958.

Author describes interesting tests on a diffusor inlet with perforation that acts as a bypass value.

Many graphs and schlieren pictures of the internal flow are given; also a short theoretical discussion is presented.

The tests may be seen as a worthwhile contribution to diffusor and inlet development.

S. F. Erdmann, Netherlands

4784. Bray, K. N. C., Atomic recombination in a hypersonic wind-tunnel nozzle, *J. Fluid Mech.* **6,** 1, 1–32, July 1959.

Based on Lighthill's ideal dissociating gas [AMR **12**(1959), Rev. 2568] the effects of atomic recombination rate on one-dimensional, adiabatic flow in a hypersonic wind-tunnel are analyzed. Solution of the applicable continuity, momentum, energy, mass action, and reaction rate equations reduces to numerical integration of two simultaneous, nonlinear differential equations for the mass fraction of atoms in the mixture and the static enthalpy as functions of nozzle axial distance. A hyperbolic area variation, which approaches a conical nozzle, is assumed.

Results indicate that, once departures from chemical equilibrium occur, the flow "freezes" rapidly. Neglecting this narrow transition region between equilibrium and frozen flow, an approximate solution is developed. From this the area ratio at which freezing occurs can be calculated as a function of a dimensionless reaction-rate parameter, rate-equation temperature exponent, stagnation pressure and stagnation temperature. This ratio is shown to increase with increasing values of the first three parameters and decreasing values of the fourth. The stagnation temperature scale of Fig. 12, illustrating this relationship, appears to be inverted.

On the basis of the approximate solution, a method is presented for calculating the shortest nozzle contour consistent with maintaining equilibrium. As the corresponding expansion angle decreases along the nozzle length, reviewer infers that, for a given nozzle area ratio, the possibility of maintaining equilibrium is greater for a characteristic than for a conical nozzle. Recently Hall and Russo [WSS/CI Pap. 59-13, Oct. 1959] presented similar results for the flow of oxygen, air, and hydrogen.

H. E. Brandmaier, USA

4785. Taylor, B. W., Development of a thin film heat-transfer gauge for shock-tube flows, Univ. Toronto, Inst. Aerophys. TN-27, 34 pp., June 1959.

Construction of a thin platinum film heat-transfer gage is described. The Pt is applied in solution to glass using a drafting pen and then baked at 1250°F. It is calibrated in a Wheatstone bridge circuit by discharging a condenser through it. With a properly constructed gage the theoretical $(\text{time})^{-\frac{1}{2}}$ law must be obeyed. Measurements are described, using a film gage at the stagnation line of a glass cylinder in a 2 × 2-inch combustion-driven shock tube. It is found that in the shock Mach number range of 5–8.5 at a channel pressure of 25 mm Hg measurements of heat-transfer rate and stagnation temperature agree well with the theory of L. Lees [AMR **9**(1956), Rev. 3390]. Wall-mounted gages were also used to obtain shock-speed readings. Sample calculations are given in the appendix.

P. Savic, Canada

4786. Mahaffey, H. A., Blocking in the open-jet wind tunnel Mass. Inst. Technol., Naval Supersonic Lab. TR 388, 56 pp., Oct. 1959.

It is desirable to have an accurate method of predicting the limitations on model size that will operate in any particular wind tunnel.

Previous work has generally established such a method for closed-jet wind tunnels.

For high Mach number and high-temperature testing it is often preferable to have a continuous flow open-jet wind tunnel. Therefore it is necessary to establish blocking prediction criteria for such a tunnel.

Criteria were established for the NSL, M = 4.80 open-jet wind tunnel. Two limits on model size and shape were found; (1) a maximum model frontal area; and (2) a maximum bow shock strength, independent of model frontal area.

Additional factors affecting blocking were found to be stagnation pressure, stagnation temperature and diffusor efficiency. No method of evaluating these additional effects was found.

The blocking criteria should be applicable for any continuous flow open-jet wind tunnel, with the limits determined by the particular tunnel circuit. From author's summary

4787. Katzoff, S., and Barger, R. L., Boundary-induced downwash due to lift in a two-dimensional slotted wind tunnel, NASA TR R-25, 19 pp., 1959.

See AMR **12**(1959), Rev. 355.

4788. Van Tassell, W. F., and Covert, E. E., Relaxation effects of the interpretation of impact-probe measurements, *J. Aero/Space Sci.* **27,** 2, 147-148 (Readers' Forum), Feb. 1960.

The purpose of this report is to present the results of some preliminary experiments designed to aid in the interpretation of impact-tube measurements. The departure from equilibrium has been related to relaxation of the internal degrees of freedom in the molecules comprising the flow field.

The experimental data presented were taken at a Mach number 4.8 in a hypersonic wind tunnel.

From authors' summary

4789. Numachi, F., Nakamura, M., and Chida, I., Cavitation tests on hydrofoil of simple form: Rep. 7, On four profiles of 7 and 11.7 per cent thickness ratios; Rep. 8, On six profiles of 15 per cent thickness ratio; Rep. 9, On four profiles of 4 per cent thickness ratio; Rep. 10, On two profiles respectively of 7 and 3.5 per cent thickness ratios, *Rep. Inst. High Speed Mech., Tohoku Univ.* **10,** 41-128, 1959.

These four papers report results of water-tunnel tests on 18 hydrofoil sections having thickness ratios of 3.5, 4, 7, 11.7 or 15 per cent. Tabulated data give lift and drag coefficients of each profile for suitable ranges of attack angle and cavitation number. The cavitation performance of the various sections is illustrated by means of cavitation diagrams. The occurrence of blade vibrations is correlated with the state of cavitation development on the foils whenever buffeting was found to exist. These papers, in English, from Tohoku University are part of a series which compares the hydrodynamic performance of forty profiles of simple form. Reviews of previous papers in this series will be found in AMR **11**(1958), Revs. 4071, 4072, 4073 and 4074; AMR **12**(1959), Rev. 2445. B. R. Parkin, USA

4790. Schult, E. D., Free-flight investigation at Mach numbers between 0.5 and 1.7 of the zero-lift rolling effectiveness and drag of various surface, spoiler, and jet controls on an 80° delta-wing missile, NASA TN D-205, 47 pp., Feb. 1960.

Tests were made of various deflected surfaces, spoilers, and inlet-air-jet devices to substantiate simple theory for deflected surfaces, and to determine some effects of chordwise location for spoilers and blowing direction and spanwise location for jets. The fuselage shape was modified for one case. The results demonstrate that all controls were satisfactory roll-producing devices except the canards immediately forward of the main wings and the spoilers at other than trailing-edge locations.

From author's summary

4791. Douvillier, J. G., Jr., Turner, H. L., McLean, J. D., and Heinle, D. R., Effects of flight simulator motion on pilots' performance of tracking tasks, NASA TN D-143, 34 pp., Feb. 1960.

The effect of rolling and pitching motion of a flight simulator on pilots' performance of a simulated tracking task was estimated from comparisons of experimental results among flight, and motionless and moving simulators. Also, a comparison between two different radar tracking displays was obtained from the flight tests. From authors' summary

4792. Vallee, P., Pris, R., and Bonvalet, C., Aerodynamic study of the French Pavilion at the Brussels International Exhibition, 1958 (in French), *Publ. Int. Assn. Bridge Struct. Engng.* **18,** 273-296, 1958.

The French Pavilion at the Brussels International Exhibition 1958 was an original design without precedent. The building covers an area of 12,000 m^2 without intermediate supports, owing to the construction of a roof in hyperbolic paraboloids carried by stretched cables on a steel framework. The unconventional design coupled with the large size of the building made it necessary to check the calculations in accordance with the N. V. 1956 regulations by means of aerodynamic tests in order to determine the general stability, local stresses and the strain in the cables.

M. H. Bertram, USA

Thermodynamics

(See also Revs. 4686, 4759, 4784, 4828, 4873, 4962)

Book—4793. Ocheduszko, S., Theory of heat engines, Part 1: Fundamentals of engineering thermodynamics [Teoria maszyn cieplynch, Czesc Pierwsza, Podstawy termodynamiki technicznej], Warszawa, Panstwowe Wydawnictwa Techniczne, 1957, xi + 455 pp. + 169 pp. of tables. zl. 92.

This text is designed for students of mechanical engineering, but the wealth of data contained makes it a very valuable reference for practicing engineers. Selection and presentation of material differs greatly from that common in modern American and English texts. The concept of temperature is only very briefly discussed in an introductory chapter. The next nine chapters deal with the First Law of Thermodynamics and its applications. While the discussion is extremely thorough and covers, e.g., open systems in nonsteady state, caloric properties of solids, liquids and vapors, together with a brief description of kinetic theory and even quantum mechanical considerations, the formulation of the First Law is, in the reviewer's opinion, somewhat confusing. The distinction between energy, work, and heat is not always clear and the terms energy and enthalpy are sometimes used interchangeably. The latter is also referred to as Gibb's function. Author devotes a great deal of attention to energy balances and calculation of work in numerous applications. Reviewer believes the consistent use of the mechanical equivalent of heat in equations superfluous, in the light of the recent definition of the international heat units in terms of the joule. This part of the book is perhaps the weakest and the presentation inferior, in reviewer's opinion, to such texts as Zemansky, Keenan or Rogers and Mayhew.

The next seven chapters deal with the Second and Third Laws of Thermodynamics and include, in addition to the usual material, a brief discussion of the relationship between entropy and probability and of thermodynamic potentials. The contents are similar to Schmidt's text. The omission of any reference to thermodynamics of irreversible processes is, perhaps, the only weakness of this section.

The next ten chapters are quite unique in the depth of treatment of the thermodynamics of real gases, vapors and mixtures. Most impressive is the discussion of relations between thermodynamic

properties and their application to equations of state. An extensive treatment of experimental data, empirical and semiempirical equations of state is included.

The last eight chapters deal with one-dimensional compressible flow with particular reference to nozzles, pipelines, seals, flow measurement and ejectors. The material and the presentation are similar to that of Stodola's text but the treatment is somewhat more detailed. Conspicuously absent is a discussion of other than normal shock formations in nozzles.

The book presents a vast amount of detailed information on the thermodynamic behavior of real substances; but many formulas are quoted without proof or discussion. 169 pages of property tables are appended. In contrast to the usual coverage in American college texts, no reference is made to applications, such as specific power cycles, or to heat transfer.

In summary the text provides a very comprehensive treatise on thermodynamics from the point of view of a mechanical engineer and an interesting insight into the scope of instruction in thermodynamics at Polish universities.

J. R. Moszynski, USA

4794. Elrod, H. G., Jr., Deduction of mass-mean properties from a knowledge of pressure and mean density, *J. Aero/Space Sci.* **26,** 7, p. 460 (Readers' Forum), July 1959.

Author proves that the necessary and sufficient condition for the mean internal energy per unit mass of pure substance at uniform pressure and nonuniform temperature to equal internal energy per unit mass evaluated at the mean density is that the relation between internal energy u, the pressure p, and the density ρ, must have the form

$$u = A(p) + B(p)/\rho \qquad [1]$$

where A and B are any functions of pressure. This result allows evaluation of the mean internal energy from the mean density without knowledge of the temperature distribution for all substances obeying [1]. The proof applies as well for any extensive property expressed as a function of pressure and density.

G. N. Hatsopoulos, USA

4795. Hirschfelder, J. O., and Secrest, D., Heat conductivity in a non-equilibrium chemically reacting gas, Part I, Univ. Wisconsin, Theoretical Chem. Lab. WIS-AF-14, 33 pp., Dec. 1959.

The diffusion and energy equations are formulated for a one-dimensional thermal-conductivity cell containing a dissociating gas comprising three molecular species. Numerical solutions are presented for six particular examples, using thermodynamic data roughly appropriate to the system H_2-I_2-HI, but with diffusion coefficients and (true) thermal conductivity independent of temperature and composition. A "two-zone" approximate procedure was also used, with varying success.

As presented, the mathematical problem involves the integration of two simultaneous first-order nonlinear ordinary differential equations with two-point boundary conditions; an eigenvalue is to be determined. Authors make repeated applications of the Runge-Kutta procedure from both boundaries until solutions join in middle of range of integration. Reviewer opines that less computational difficulty is presented by formulation of single second-order differential equation which may be solved, with due respect to the boundary conditions, by successive-adjustment or iterative-quadrature procedures.

D. B. Spalding, England

4796. Prausnitz, J. M., Hypothetical standard states and the thermodynamics of high-pressure phase equilibria, *AIChE J.* **6,** 1, 78-82, Mar. 1960.

Thermodynamic analysis of phase-equilibrium data is necessary for testing such data, for extension to new conditions, and for purposes of correlation and prediction of phase-equilibrium behavior. While such analysis is common for low-pressure systems, it is rare for high-pressure systems owing to difficulties encountered in the definition of standard states. For a gaseous solute in the liquid phase it is proposed that the standard state be taken as the hypothetical liquid at the temperature and total pressure of the solution. The properties of this standard state are specified by the temperature and total pressure and by the specific volume which the substance would have if it did not experience a phase change. This standard state is useful since it is not a function of the solution but only of the substance being considered. For a condensable component in the gas phase it is convenient for most purposes to define the standard state as the ideal gas at the temperature and total pressure of the solution; but to separate the effect of composition on the activity coefficient from that of pressure, it is proposed to define the standard state as the real hypothetical gas at the solution conditions. To illustrate these ideas, activity coefficients are computed for several high-pressure systems, and it is shown how these activity coefficients may be used in the correlation, testing, and extension of high-pressure phase-equilibrium data.

From author's summary

4797. Lambert, J. D., and Salter, R., Vibrational relaxation in gases, *Proc. Roy. Soc. Lond.* (*A*) **253,** 1273, 277-288, Nov. 1959.

Velocity of ultrasonic waves was measured at 25 C for number of gases over range of values of ratio ultrasonic frequency/pressure from 2×10^5 to 2×10^7 c. sec^{-1} atm^{-1}. Gases include ethane, propane, *n*-butane, isobutane, neopentane, hexafluoro- and 1.1 difluoro-ethane, ethyl chloride, ethyl fluoride, acetylene dimethyl ether, CD_3Br and ammonia. Acoustic interferometers of type described by Lambert and Robinson [*Proc. Roy. Soc.* (*A*) **204,** p. 424, 1950] were used. One operated at basic frequency 240 kc/s, the other at 4 mc/s. Higher frequency unit was kept in thermostat to 0.1 C and wavelength of ultrasonic wave in gas measured to 5 microns. Pressure range 1 atm. to 0.1 atm.

Results are compared with previously published data. Conclusions drawn are: (a) for types of molecules having narrow gap between lowest and other fundamental frequencies of vibration, a single relaxation process will describe results; (b) if a larger gap exists between lowest and other frequencies a double relaxation occurs; (c) torsion oscillation modes can be considered in the same way as other modes, and rules (a) and (b) apply.

From authors' summary by K. W. Hillier, England

4798. King, C. R., Compilation of thermodynamic properties, transport properties, and theoretical rocket performance of gaseous hydrogen, NASA TN D-275, 71 pp., Apr. 1960.

Data were computed assuming equilibrium composition during an isentropic expansion using normal hydrogen as the propellant for chamber pressures from 0.146960 to 1469.60 lb/sq in. abs, pressure ratios from 1 to 3000, and chamber temperatures from 600° to 5000°K. Computed parameters are nozzle-exit pressure and temperature, enthalpy, molecular weight, isentropic exponent, specific heat at constant pressure, absolute viscosity, thermal conductivity, Mach number, specific impulse in vacuum, ratio of nozzle-exit to throat areas, thrust coefficient, specific impulse, equilibrium gas composition, characteristic velocity, and entropy.

Additional data show some of the properties of gaseous normal hydrogen, orthohydrogen, and parahydrogen at temperatures below 600°K for several pressures.

From author's summary

4799. Fay, Gy., and Tabori, G., Discussion of the time-lapse of thermodynamic processes (in German), *Acta Physica, Acad. Sci. Hungaricae* **10,** 2, 129-133, 1959.

4800. Lighthill, M. J., Dynamics of a dissociating gas, Advances in Aeronautical Sciences, Vol. 1 (Proc. of the First

International Congress in the Aeronautical Sciences, Madrid, Sept. 8–13, 1958), Pergamon Press, 1959, 120–126.

Book—4801. Eisenschitz, R., Statistical theory of irreversible processes, London, Oxford University Press, 1958, viii + 84 pp. $2.

The subject of this small monograph is the microphysical theory of irreversible processes in gases, liquids and solids. After a short review of equilibrium statistical mechanics, Kirkwood's "time-smoothing" is introduced. (The author calls it "coarse graining," although he defines coarse graining in a different way.) The resulting Boltzmann equation is used to compute the coefficients of viscosity and of thermal conductivity in dilute gases. The resulting Fokker-Planck equation is applied to liquids. Subsequently the quantum mechanical theory is cast in a form very similar to the classical theory by means of the Wigner distribution function, and the Uehling-Uhlenbeck equation is given. The solid state and its heat conduction through phonons are briefly treated. Finally, the elementary theory of Brownian movement and stochastic processes is given.

The exposition is brief, skipping many algebraic manipulations, and at times takes the form of a review paper. In this way the logical structure of the theory is made very clear, but the reading will not be easy for tiros. In making the basic step from reversible to irreversible equations the author follows mainly Kirkwood, and is accordingly rather optimistic. The equation $f^{(2)}(1, 2) = f^{(1)}(1) f^{(1)}(2)$ is introduced without comment. The criterion for the validity of the Fokker-Planck equation is stated incorrectly. In the quantum mechanical part the occurrence of irreversibility is attributed to external perturbation, which is incorrect, and not comparable with the coarse graining of classical mechanics, as the author asserts. On the other hand, there are a number of interesting remarks, which, together with the clear and coherent development of the theory, make the book worth reading.

N. G. van Kampen, Netherlands
Courtesy Mathematical Reviews

4802. Prigogine, I., and Balescu, R., Irreversible processes in gases: Part I, The diagram technique; Part II, The equations of evolution, *Physica* **25,** 4, 281–323, Apr. 1959.

The asymptotic behavior of the distribution function $f_N(t, p_1, \ldots, p_N, x_1, \ldots, x_N)$ of a gas in a volume Ω is discussed for $N \to \infty$, $\Omega \to \infty$, $N/\Omega = \text{const}$, and $t \to \infty$, on the basis of its Fourier coefficients $\rho_{k\alpha \ldots k\nu}(t, p_1, \ldots, p_N)$. The Fourier expansion of Liouville's equation in phase space is treated by iteration, introducing time integrations over successive matrix elements of the Liouville operator connecting two Fourier components. These are represented by diagrams, and it is shown that they have an asymptotic behavior which depends on their topology. A simple inspection of these diagrams leads then, with the help of a few simple rules, to a complete asymptotic analysis of their contributions to the distribution function. For important classes of initial conditions and for large systems, it is possible to replace the infinite set of equations by a closed set involving only a few types of Fourier coefficients. For long times these reduced equations give directly the approach to equilibrium. While the transformation for f_N is unitary, the transformation law for some of its Fourier components and the corresponding reduced distribution functions is self-adjoint, so that their approach to equilibrium is monotonic.

The method is succesfully applied to weakly coupled homogeneous gases in the first and second approximations, to weakly coupled inhomogeneous systems, where, in the second approximation, it gives a term considered by Vlassov, and to strong interactions in dilute gases. P. E. Kriezis, Greece

4803. Shtenbeck, M., and Baranskii, P. I., An experimental study of the relation between the Peltier effect and thermoelectromotive forces in germanium, *Soviet Phys.-Tech. Phys.* **2,** 2, 205–209, Feb. 1957. (Translation of *Zh. Tekh. Fiz., USSR* **27,** 2, 233–237, Feb. 1957 by Amer. Inst. Phys., Inc., New York, N. Y.)

New results are published concerning the relation between the Peltier coefficient P and the differential thermoelectromotive force α in samples of n-type and p-type germanium which confirm that for impurity conductivity $P \neq \alpha T$, as was previously established by the authors.

For intrinsic conductivity the values of P and α obtained for the same samples satisfied $P = \alpha T$. From the data for $P = P(t)$ [as distinct from the data for $\alpha = \alpha(T)$] it was possible to estimate the specific heat of the carrier gas (electrons and holes), which agrees with the specific heat of a classical ideal gas $3/2\ k$ within the limits of experimental error.

S. Lampert, USA

4804. Boerdijk, A. H., Contribution to a general theory of thermocouples, *J. Appl. Phys.* **30,** 7, 1080–1083, July 1959.

Application of thermodynamics of irreversible processes to a thermocouple of which (a) the bars have an arbitrary shape, (b) the properties of the materials are arbitrary functions of temperature, and (c) the composition is, under certain restrictions, inhomogeneous and anisotropic, leads, through introduction of a single-place coordinate, to two nonlinear differential equations describing the stationary distribution of temperature and electrical potential. Output powers and efficiencies are expressed in terms of the temperature gradients in the bars. The maximal values of the efficiencies obtained by variation of the shape of the bars are independent of the shape. Upper bounds of the efficiencies attainable by stationary thermoelectric conversion are derived. If the shape of the bars is restricted to general cylinder and truncated wedges or cones the transient behavior is described by two partial differential equations which contain two independent variables only. A periodic ripple in the electrical current has the same effect as a decrease of the electrical conductivities of the materials.

From author's summary by N. A. Hall, USA

4805. Beck, J. V., and Hurwicz, H., Effect of thermocouple cavity on heat sink temperature, *ASME Trans.* **82** C (*J. Heat. Transfer*), 1, 27–36, Feb. 1960.

Analytical and machine solutions are presented for the local disturbances of the temperature field in a heat sink (semi-infinite solid) caused by the presence of a (cylindrical rod) thermocouple installed with its axis normal to the heat-sink surface and with its end at various distances within the solid (as measured from the exposed heat-sink surface). Both transient and steady-state solutions are given. Applications are indicated to transient aerodynamic heating experiments. Design and data-analysis considerations are discussed for: (1) the "hot spot" temperature disturbance created by the thermocouple, and (2) the difference between the true surface temperature and the thermocouple indication. Optimum thermocouple location is found where undisturbed surface temperature may be read most closely. Calculation results are presented graphically. H. B. Nottage, USA

4806. Thureau, P., Study of temperature measurement using the heat sensibility of fluorescent paints (in French), *Publ. Scient. Tech. Min. Air, France* no. 349, 128 pp., 1959.

Using the change of color of fluorescent paints has the advantage of being independent of the excitation intensity. The ratio of intensities of two wavelengths is determined by multipliers and interferential filters. Good results were obtained when a green zinc sulfide or anthracene were exited by modulated ultra-violet light of a mercury vapor lamp.

The method is applied to aerodynamic experiments. Free particles of the fluorescent phosphors in an air stream indicate the static temperature. Paints on the surface of models in supersonic flow allow the measurement of local surface temperatures. Results for models of copper and plexiglass are given and discussed. Author is convinced that the method may be extended to higher temperatures by a study of other fluorescent substances.

H. I. Behrens, Germany

4807. Krauss, F., The measurement of specific heats in metals at high temperatures (in German), *Z. Metallk.* **49**, 7, 386–392, July 1958.

The specific heat at constant pressure, c_p, as a function of the temperature was determined for chromium from 690 to 1320°C. The sample, made of chromium of the highest purity (99.96% Cr, 0.04% O_2), was in the shape of a hollow cylinder placed within an evacuated furnace. Heating of the sample was accomplished by means of a tungsten spiral mounted within the cylinder to which a known amount of electrical energy was delivered during a short time interval (10 to 20 sec), producing a small temperature rise (of the order of a few degrees) which was measured with the aid of Pt-PtRh thermocouples. The results are shown graphically and tabulated. The value of c_p, in cal/gm C°, rises fairly uniformly from 0.151 at 700°C to 0.178 at 1100°C, then increases more rapidly. The experimental error at 1100°C is estimated as 1%.

An appendix contains more recent data obtained by H. A. Martin in author's laboratory, employing essentially the same method as Krauss. The value of c_p for chromium as a function of the temperature from 600 to 1430°C is shown graphically and in tabular form. Martin's values are somewhat lower than Krauss's in the common temperature interval, increasing from 0.142 at 700°C to 0.166 at 1100°C. They then rise rapidly, reach 0.36 at 1360°C, indicate a transition point at 1375°C, then fall to about 0.28 near 1400°C. The experimental error at 1300°C is estimated as 3%. Evidence for a transition near 1400°C was first obtained by T. R. McGuire and C. J. Kriessman [*Physical Review* **85**, 3, 452–454, 1952] from measurements of the magnetic susceptibility of chromium.

A second appendix reports briefly on unpublished measurements of c_p for pure iron from 100 to 1440°C as performed in 1951 by H. Holetzko, using the method of dropping a cold body of known thermal capacity in a cavity within the heated sample and measuring the small fall of temperature produced. The results are presented both graphically and in tabulated form and compared with the findings of earlier investigators. The temperatures at the transition points A_2, A_3, A_4 were determined as 755, 906, and 1395°C.

R. Heller, USA

Heat and Mass Transfer

(See also Revs. 4548, 4574, 4651, 4668, 4683, 4763, 4785, 4795, 4804, 4805, 4806, 4847, 4872, 4941, 4945, 4962)

Book—4808. Lykov, A. V., and Mikhailov, Yu. A., Theory of energy and mass transfer [Teoriya perenosa energii i veshchestva], Minsk, Izdatel'stvo Akademii Nauk BSSR, 1959, 330 pp. 13r.

Book deals with solution, for various boundary and initial conditions, of the equation system

$$\frac{\partial t}{\partial \tau} = a\nabla^2 t + \frac{\varepsilon\rho}{c}\frac{\partial u}{\partial \tau}, \qquad \frac{\partial u}{\partial \tau} = a'\nabla^2(u + \delta t)$$

where t is temperature of wet porous body (e.g., beam of wood), u = density of moisture, $u_1 (\ll u)$ density of vapor (in the pores of the body), ρ heat of evaporation. a, a' are suitably defined thermal and mass diffusivities, ε, δ are suitably defined interaction coefficients. In an introductory chapter the governing equations are established, and irreversible thermodynamics briefly discussed. In Chapters 2, 3, 4, the equations are solved for one space dimension (slab, sphere, cylinder) for a multitude of initial and boundary conditions, using, usually, Laplace transformation with respect to time; but in cases where surface flux is prescribed, finite Fourier or Hankel transforms are used with respect to the space coordinate. Much space is devoted to tabulating and plotting the roots μ_n of various eigenvalue equations which arise in the course of the solution, such as

$$(A_2 \cos \mu\alpha_2 + B_2\mu \sin \mu\alpha_2)(C_1 \cos \mu\beta_1 + D_1\mu \sin \mu\beta_1) +$$
$$(A_1 \cos \mu\alpha_1 + B_1\mu \sin \mu\alpha_1)(C_2 \cos \mu\beta_2 + D_2\mu \sin \mu\beta_2) = 0$$

$$\cot \mu = C\mu, \quad J_0(\mu) = C\mu J_1(\mu), \quad \mu \cot \mu\alpha +$$
$$B\mu \cot \mu\beta + C = 0, \text{ etc.}$$

in their dependence on the problems' various dimensionless parameters. Among these the following are prominent: Lu-number (ratio of mass and heat diffusivity), Biot number for heat and mass transfer, Posnov number (dimensionless δ), Kossovitch number (dimensionless ρ), Fedorov number (the product $\varepsilon\, Pn\, Ko$), and various less relevant parameters. The solutions' dependence on the parameters is extensively illustrated and discussed. Chapter 5 deals with slab problems involving two space dimensions (x and y); the final chapter, 6, incorporates the effect of fluid flow terms resulting from pressure gradients.

The book is primarily mathematical; a few pages are devoted to discussion of experimental determination of some of the pertinent parameters; little is said about applications. The various solutions obtained are credited to S. P. Kuznetsov, E. I. Sizyakov, F. M. Polonskaya, P. D. Lebedev, M. S. Smirnov, and the authors.

G. Horvay, USA

4809. Dlouhy, J., and Gauvin, W. H., Heat and mass transfer in spray drying, *AIChE J.* **6**, 1, 29–34, Mar. 1960.

Studies of the evaporation and drying rates in an experimental concurrent spray dryer, 8 in. in diameter and 14 ft high, are reported for various operating air temperatures. It was found that the total evaporation and drying time could be accurately predicted by employing a step-by-step method of calculation. Owing to the probable absence of internal diffusional resistance in the small particles, less than 30 μ, produced in the dryer, no significant falling-rate period was observed. This was in marked contrast with tray-drying experiments carried out on the same substance, under similar drying conditions. The results also confirmed that a Nusselt number of 2 can safely be used in spray-drying heat-transfer calculations.

From authors' summary

4810. Krasnikov, V. V., Heat- and mass-exchange in the process of contact drying (in Russian), *Sb. Rabot-Vses. Zaochn. In-ta Pishch. Prom-sti* no. 3, 36–48, 1958; *Ref. Zh. Mekh.* no. 2, 1959, Rev. 1575.

Contact drying is widely employed in the paper industry. These investigations throw additional light on the mechanism of the drying of cellulose on a heated surface. In the drying process, two processes take place concurrently and in interconnection: (a) a conduction heat exchange between the heating surface and the moist body, complicated by the transfer of matter; (b) a process of vapor formation in the contact layer accompanied by the absorption of the heat of the vapor and the transfer of heat inside the material by the steam making its way to the open surface of the material. The greater the overheating of the layer of the body in direct contact with the heating surface, the greater will be the pressure gradient. The transposition of a mass of vapor inside a capillary-porous body under the action of a general pressure gradient emerg-

ing from the contact layer of material is analogous to the process of the filtration of a gas through porous media. The filtration coefficient (k_p) increases sharply with the decrease in thickness (specific mass) of the material. For instance, with a thickness for the decanted material of 0.22 mm (150 g/m³) $k_p = 113 \times 10^{-6}$ kg/m hr mm of mercury and with a thickness of 0.72 mm (500 g/m³) $k_p = 37.5 \times 10^{-6}$ kg/m hr mm of mercury. The principles of the interior heat and mass exchange during contact drying are recorded by means of a system of differential equations, expressing the transfer of heat in a capillary-porous body, the transfer of liquid and the transfer of vapor under the influence of the pressure gradient.

S. D. Krongauz

Courtesy Referativnyi Zhurnal, USSR

4811. Balazsovics, G., Theoretical investigation of heat- and mass-transfer processes in calcination (in German), Radex Rundschau no. 1, 434–454, Jan. 1959.

Paper is an attempt to synthesize the data from experiments by Wuhrer and Azbe with appropriate approximate analysis to determine the heat and mass transfer in the calcination of calcium carbonate. The analytical model under investigation was spherical in shape as a matter of mathematical convenience. The calcination process was considered to be much slower than the time required for heat flow so that, as a simplification, the heat capacity of the calcium carbonate core could be neglected. The heat then conducted through the CaO shell was needed only in the quantity required to support the decomposition process of the $CaCO_3$. The CO_2 generated in the decomposition process diffused through the CaO shell. Both heat transfer and mass transfer were calculated. Results are given in terms of mathematical formulation for the following:

(a) Surface temperature as a function of heat exchange and degree of calcination.
(b) The heat transfer at the surface.
(c) The partial pressure of the carbon dioxide product at the surface.
(d) The mass transfer from the surface.

The reaction temperature and the vapor pressure of the carbon dioxide and the calcium carbonate were determined by a graphical technique. The paper concludes with a discussion of the magnitude of the error associated with the approximations made, and a discussion of the calculation difficulties.

R. M. Drake, Jr., USA

4812. Meyer-Hartwig, E., Heat conduction and boundary layer formation for various materials used for sweat cooling (in German), Jahrbuch Wissenschaft. Gesellsch. Luftfahrt, 1957, 439–468.

Paper is based on research done in 1941–43 and apparently now published for first time. The work is not up-dated as shown by the lack of references to Dutch and U.S. literature, but it does contain much useful information. Temperature profile through a porous sweat-cooled surface is derived and experimentally checked by porous wall made of wire bundle. Second portion of paper deals with manufacture and properties of porous materials, such as strength and porosity. Experiments were made on surface temperatures with 1100°C gas, and water and air as the cooling agent.

A. C. Mueller, USA

4813. Shvets, I. T., and Diban, E. P., The cooling of the disks of gas turbines by means of blowing air through the butt end of working blades (in Russian), Mekh.-Mat. Fak. Kievsk. In-ta, 1956; Kiev, 1957, 539–543; *Ref. Zh. Mekh.* no. 2, 1959, Rev. 1586.

This is a review of investigations which made it possible to work out procedures for engineering heat and hydraulic calculations for cooling systems for disks of gas turbines by means of forcing cooling air through the assembly clearances of the articulated points of the blades and the disk. The small influence of the disk profile on its temperature field makes it possible to use in the calculations an equation derived for a disk of constant thickness. The coefficients of heat transfer can be taken from the corresponding experiments, which showed that heat loss from the side of the lateral surface of the disk does not exceed 400 kcal/m² hr °C, while in the assembly clearances of the blades' articulations it exceeds 500 kcal/m² hr °C. The area of the surface of the assembly clearances is of an order equalling the area of the lateral surfaces of the disk, while the temperature pressure in the slot chambers is considerably higher; consequently this method of cooling the disk proves to be effective. The hydraulic calculation for the cooling system merges with the determination of the necessary initial air pressure and is carried out by the usual procedure, utilizing experimental data.

V. Kh. Abiants

Courtesy Referativnyi Zhurnal, USSR

4814. Danilova, I. N., Temperature distribution in an infinite hollow cylinder with boundary heat transfer to media of variable and constant temperature (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 12, 148–150, Dec. 1958.

Author gives solution for transient temperature field with the following boundary conditions: (a) Initial temperature of cylinder uniform; (b) inside fluid temperature and heat-transfer coefficient constant; (c) outside fluid temperature varies linearly with time and outside heat-transfer coefficient constant.

Y. R. Mayhew, England

4815. Horvay, G., Freezing of a growing liquid column, *ASME Trans.* **82** C (*J. Heat Transfer*), 1, 37–47, Feb. 1960.

Exact and approximate treatments are given for one-dimensional heat flow through layer of liquid with lower surface maintained at a fixed temperature and with addition of hot liquid from above at steady rate. The approximate treatment (based on analogous electric circuits with lumped impedances) is then applied to cases with lower temperature below freezing point and with a solidification front moving up through the liquid, to provide a model for casting of metals. Heat transfer in the body of the liquid is treated as due solely to conduction.

Reviewer regards mathematical treatment of the problems chosen as satisfactory but feels that a much fuller discussion of physical aspects should have been given. Convective heat transfer is potentially much more effective than conductive transfer and author should have discussed conditions when it might be neglected. Also in first problem the temporary fall in temperature arises from the unreal initial condition of a temperature discontinuity at lower face.

B. R. Morton, England

4816. Hofmann, R., On the solution of special heat transfer problems (in German), *ZAMP* **10**, 3, 233–244, May 1959.

Author applies the Laplace transformation method and inversion theorem in a quite general manner to the case of the cylinder, sphere and cube, having in view technical needs. The method used has been under development for several decades, beginning with the rigorous treatment of the application of the Laplace transform by Bromwich (1916), Jeffreys (1931) and Carslaw and Jaeger (1959). Author's purpose is directed to indicating the superiority of the "transformation" method and its advantages as the complexity of the problems to be solved increases.

F. G. Keyes, USA

4817. Barzelay, M. E., Range of interface thermal conductance for aircraft joints, NASA TN D-426, 63 pp., May 1960.

More than 100 aluminum-alloy and high-temperature-alloy structural-joint specimens consisting of a stringer joined to a skin surface were tested under simulated aerodynamic heating conditions. Interface thermal conductance was determined from

transient temperature records. Most of the specimens were geometrically identical and of the same aluminum alloy in order to take into account the effect of manufacturing variability and of many different types of fastenings; the heat input was nearly constant during any given test; mean interface temperatures as high as 600°F were achieved during the transient heating; and most of the tests were conducted during a period of less than 1 minute.

From author's summary

4818. Sogin, H. H., Laminar transfer from isothermal spanwise strips on a flat plate, *ASME Trans.* **82**C (*J. Heat Transfer*), 1, 53–63, Feb. 1960.

Heat-transfer rates from one and two isothermal spanwise strips located in tandem on a flat plate with a laminar boundary layer are determined analytically. The Rubesin-Klein-Tribus method is used. The analogous mass transfer process is studied experimentally by measuring rates of sublimation from naphthalene strips on a flat plate in a wind tunnel. Generally good agreement was found between average transfer rates for each strip as predicted and observed. The experimental studies were extended to as many as seven equally-spaced strips with notation of the effects of roughness and spanwise diffusion.

J. E. Plapp, USA

4819. Napolitano, L. G., and Pozzi, A., Laminar mixing of streams of different gases, AFOSR TN 59–977 (Univ. of Naples, Istituto di Aeronautica TN-1), 60 pp., Apr. 1959.

The interdiffusion of two gases flowing at constant but different temperatures, pressures, and velocities, parallel and in contact with each other, is studied. Exact closed-form solution for the isovel case for the Lewis number $\neq 1$, and exact computing machine solutions for some typical cases are obtained. An approximate simple method based on the integral technique is developed for the general case, and is shown to be adequate for all practical cases. Maximum errors are less than 3% for velocity profiles, and are at low weight ratios of the two gases. Concentration profiles are somewhat less accurate.

Exact and approximate solutions are used to determine the error due to the usual assumption that $(\rho\mu)$ is constant at unity. It is shown that the error can reach 50% in practical cases.

From authors' summary by C. F. Bonilla, USA

4820. Tendeland, T., Effects of Mach number and wall-temperature ratio on turbulent heat transfer at Mach numbers from 3 to 5, NASA TN R-16, 15 pp., 1959.

See AMR **11**(1958), Rev. 5160.

4821. Deissler, R. G., and Taylor, M. F., Analysis of turbulent flow and heat transfer in noncircular passages, NASA TR R-31, 18 pp., 1959.

See AMR **12**(1959), Rev. 2601.

4822. Deissler, R. G., and Loeffler, A. L., Jr., Analysis of turbulent flow and heat transfer on a flat plate at high Mach numbers with variable fluid properties, NASA TR R-17, 33 pp., 1959.

See AMR **11**(1958), Rev. 5089.

4823. Wrage, E., Application of the Gortler series for the computation of temperature boundary layers (in German), Dtch. Versuchsanstalt Luftfahrt Ber. 81, 45 pp., Dec. 1958.

Solution of temperature boundary-layer problems in constant property liquids is given as an infinite series using the boundary-layer coordinates proposed by H. Görtler for calculating the velocity field. The equations governing the temperature field have been set up in terms of universal functions. It is indicated that the solution of the thermometer problem for given wall temperature and the temperature distribution in the boundary layer for mixed boundary conditions can be obtained by this method. Tables of universal functions which will be required for getting numerical results are promised in the second part of the report to be published in near future.

S. D. Nigam, India

4824. Bobco, R. P., A closed-form solution for laminar free convection on a vertical plate with prescribed, nonuniform, wall heat flux, *J. Aero/Space Sci.* **26,** 12, 846–847 (Readers' Forum), Dec. 1959.

Author describes an approximate method based on integration by parts and neglect of the residual integral. A comparison presented between two solutions, one based on author's approach, and the other on a solution due to Sparrow [NACA TN 3508; AMR **9**(1956), Rev. 1611] for the case of uniform heat flux, indicates the error associated with this particular approximation.

T. D. Patten, Scotland

4825. Gross, E. P., and Ziering, S., Heat flow between parallel plates, *Physics of Fluids* **2,** 6, 701–712, Nov./Dec. 1959.

Paper deals with the problem of finding appropriate solutions of the Boltzmann equation which are valid for every ratio of the mean free path to the distance between the plates. For this purpose the conventional expansion procedure is modified in such a way that independent distributions are employed for those molecules which are moving in direction of the temperature gradient and those which are moving in opposite direction. A relatively simple and accurate solution is established, covering ordinary conduction of heat, Knudsen flow and the intermediate "slip distance" range. Possible improvements and simplifications of the deductions are considered in much detail.

Whereas there is plenty of meticulous comparison of different methods of calculation there is no discussion of the relation of calculated and experimental data.

R. Eisenschitz, England

4826. Robinson, A. R., The symmetric state of a rotating fluid differentially heated in the horizontal, *J. Fluid Mech.* **6,** 4, 599–620, Nov. 1959.

The motion of a fluid inside a rotating annulus of square cross section, whose dimensions are small compared with the distance from the axis of rotation, is considered. The rigid side walls are held at different constant temperatures, and the fluid motions which occur are strongly influenced by Coriolis accelerations. A detailed study is made of the azimuthally independent state, a Hadley cell, in the limit of small thermal Rossby number. It is convenient to employ a boundary-layer-type analysis, essentially with respect to the Taylor number, and all the imposed boundary conditions are rigorously satisfied.

An entirely geostrophic thermal wind is found to obtain over the main body of the fluid. The circulation in the plane of the annular cross section is entirely confined within narrow boundary layers and consists of a superposition of three cellular motions: a cell occupying the cross section and two additional cells confined to the side wall boundary layers. These motions are intimately related to the rotational constraint. The temperature distribution and its relation to the conductive processes are determined.

From author's summary by J. T. Stuart, England

4827. Pisarev, N. M., Axially symmetrical convection in a vertical tube during heat losses (in Russian), *Trudi Ural'skogo Politekbn. In-ta* no. 72, 225–232, 1957; *Ref. Zh. Mekh.* no. 2, 1959, Rev. 1568.

A mathematical description is given of axially symmetrical convection when heat losses to the surrounding body are being experienced by a liquid filling a vertical cylindrical cavity. A nonlinear equation is obtained which is solved approximately. All

the physical magnitudes are sought in the form of series in which the first terms are known solutions of these magnitudes in a thermally insulated model, while the second terms are their small complements produced by the presence of heat losses.

I. E. Idel'shik
Courtesy Referativnyi Zhurnal, USSR

4828. Winskell, P. L., and Hsu, S. T., Theory and design of a mechanical blackbody for solar radiation, *J. Solar Energy Sci. Engng.* **3,** 2, 1-8, Apr. 1959.

A method of increasing the absorptivity of a surface by a mechanical arrangement of the surface is given. In the theoretical model the spherical cavity is replaced by a two-dimensional parallelepiped. The predicted values of absorptivity are presented in graphical form as functions of the depth-width ratio with angles of incidence as parameters. The calculations given in the paper, even though not stated by the authors, are executed under the assumption that the inner walls of the blackbody have a uniform temperature. Actual performance of an experimental mechanical blackbody surface was determined. However, in the experimental phase of the study only the relative over-all change in the efficiency, which included both convection and radiation losses, was investigated, and the exact change in the values of absorptivity and emissivity was undetermined.

Reviewer found the paper lacking in references to previous studies on the mechanical blackbody theory and design. The advantages of the blackbody approximation by a parallelepiped element in comparison with the wedge or the tubular approximations [J. C. De Vos, *Physica* **20,** p. 690, 1954] are not discussed.

R. Viskanta, USA

4829. Bartas, J. G., and Sellers, W. H., Radiation fin effectiveness, *ASME Trans.* **82**C (*J. Heat Transfer*), 1, 73-75 (Technical Briefs), Feb. 1960.

An analytic study is made of radiative heat transfer from a heat rejector consisting of parallel tubes joined by web plates that lie in the plane of the tube center lines and act as extended surfaces. The effectiveness, or ratio of the actual heat-transfer rate to the ideal rate when the temperature of the entire surface of the web is equal to the tube temperature, is calculated as a function of a parameter that involves the spacing between the tubes, the thickness and thermal conductivity of the webs, the tube temperature, and the emissivity of the surface of the web. The relation between the effectiveness and this parameter is also determined for maximization of the heat rejection rate when the web weight is kept constant.

J. E. Plapp, USA

4830. Bucher, N., Theoretical study of high-temperature radiator panels (in French), *Schweiz. Arch.* **25,** 7, 231-254, July 1959.

In large single-story factory buildings it is often impractical to install heating coils in the floor because of heavy variable loads on it. In such cases, horizontal heating panels just below the ceiling are a good solution. Such panels usually consist of horizontal banks of tubes through which pressurized hot water is circulated at temperatures up to 200°C. To minimize heat loss from these tubes to the ceiling, reflector shields are mounted above the tubes and insulation is sometimes placed between the top of these shields and the ceiling.

In this paper the author derives the rates of heat transfer from such heating panels to the floor and to the ceiling by radiation and convection in terms of temperature difference, the geometry of the panel and the height above the floor, and the tube and floor emissivities. The agreement with experimental results is good. Efficiencies, defined as the fraction of the total heat flow which is transferred to the floor, typically range from 0.7 to 0.8 and tend to rise very slightly with increasing temperature difference.

A. W. Gessner, USA

4831. Werner, H., Calibration of radiation heat balance meters and effective pyranometers through joining to standard apparatus (in German), *Z. Meteorol.* **12,** 5, 245-248, Aug. 1958.

Author discusses some points of view which must be taken into account when carrying out the calibration of radiation heat balance meters and effective pyranometers in practice and when evaluating the readings obtained from apparatuses of different types so that the results of measuring terrestrial radiation could be uniformly expressed in energy units of $cal/cm^{-2}/min^{-1}$. Especially it is shown that if one should obtain a correct radiation balance with a heat balance meter which is not equally sensible to short and long wave radiation it is necessary at the same time to measure or register with a pyranometer the total short-wave radiation striking the earth's surface in broad day and find out the short-wave albedo of the earth's surface situated under the heat balance meter.

F. Krupka, Czechoslovakia

4832. Jontz, P. D., and Myers, J. E., The effect of dynamic surface tension on nucleate boiling coefficients, *AIChE J.* **6,** 1, 34-38, Mar. 1960.

A study was made of the effects the surface tension of aqueous solutions of surface-active agents had on the bubble-formation characteristics of these solutions. Bubbles were formed by two processes: by passing air through a horizontal orifice submerged in the solution and by nucleate boiling at an electrically heated surface. The experimental measurements taken with the air-bubble system were used to determine the nature of the surface-tension effect on air-bubble formation. This knowledge was then applied to the interpretation of boiling measurements made with the same solutions. The boiling coefficients of the Tergitol-water solution were found to vary inversely with dynamic surface tension. Boiling coefficients for aerosol-water solutions, however, varied in a manner which could not be related to surface-tension effects.

From authors' summary

4833. Kutateladze, S. S., and Moskvicheva, V. N., Hydrodynamics of a two-component layer as related to the theory of crises in the process of boiling, *Soviet Phys.-Tech. Phys.* **4,** 9, 1037-1040, Mar. 1960. (Translation of *Zh. Tekh. Fiz. USSR* **29,** 9, 1135-1139, Sept. 1959 by Amer. Inst. Phys., New York, N. Y.)

Paper is concerned with the prediction of the maximum heat flux attainable in boiling heat transfer—i.e., at the point of transition from nucleate to film boiling. The experimental work involves the vertical injection of a liquid (water) through a perforated plate into another more dense liquid (mercury or carbon tetrachloride). A detailed description of the experimental apparatus, measuring equipment and procedure is not given. The fractional cross section occupied by the lighter component is measured as a function of the light phase velocity at the orifice. The data are presented in graphical form.

Authors state that they have derived an equation from hydrodynamic principles which establishes a criterion for predicting the maximum heat flux in boiling. This criterion suggests that, for any system, the dimensionless parameter

$$F = W_0''' (\rho_L)^{1/2} [g^3\sigma(\rho_H - \rho_L)]^{-1/4}$$

is a constant at the transition point. In this equation ρ_H and ρ_L are the density of the heavier and lighter components, respectively; g is the gravitational constant; and σ is the surface or interfacial tension. W_0''' is the reduced velocity of the lighter phase given by

$$W_0''' = \frac{q}{\lambda\rho_L}$$

in which q is the heat flux and λ is the latent heat of vaporization.

The experiments with two liquid components indicated that the value of F at which the two-phase layer became unstable was near the value established for the majority of liquids during boiling, i.e., $F = 0.15$–0.18.

The analysis and the experimental data should be of interest to those interested in sieve plate performance in solvent extraction and distillation. Unfortunately, the analytical paper, which was "in press" at the time of publication, was published in another journal.

T. W. Hoffman, Canada

4834. Styrikovich, M. A., and Mostinskii, I. L., The influence of nonuniform heating of the perimeter of a tube on the critical heat flow, *Soviet Phys.-Doklady* **4,** 4, 794–797, Feb. 1960. (Translation of *Dokladi Akad. Nauk SSSR (N.S.)* **127,** 6, 316–319, July/Aug. 1959 by Amer. Inst. Phys., Inc., New York, N. Y.)

The aim of the present work is to investigate experimentally the influence of nonuniformity of the heating of the perimeter of stream-generating tubes on the critical heat flux when the water in the stream-water mixture is in vertical motion.

From authors' summary

4835. Andriyashev, M. M., Calculations for the thermal state of a pipe conduit partially filled with water (in Russian), *Vodosnabzh. i San. Tekhn.* no. 12, 1-6, 1957; *Ref. Zh. Mekh.* no. 2, 1959, Rev. 1553.

A new scheme is proposed for the approximate mathematical calculation of the thermal losses in a pipe conduit partially filled with water. An attempt is made to estimate the tangential thermal flows directed to the walls of the pipe and to the bottom near the wall. A comparison is made between the magnitudes of some experimentally determined thermal resistances of the soil and computed results. This comparison enables the author to state that consideration of the tangential thermal flows brings the computed results significantly closer to experimental results.

V. M. Deryugin

Courtesy Referativnyi Zhurnal, USSR

4836. Birt, D. C. P., Brunt, J. J., Shelton, J. T., and Watson, R. G. H., Methods of improving heat transfer from condensing steam and their application to condensers and evaporators, *Trans. Inst. Chem. Engrs.* **37,** 5, 289–296, Oct. 1959.

Use of rotating surfaces and dropwise condensation promotors (tetrakisdodecanethiosilane) to increase heat-transfer rate from condensing steam on cuprous surfaces was investigated. With rotating surfaces under conditions of filmwise condensation, an increase of h_s with rotational speed was obtained. Photographs indicate that this is due to formation in the water film of ridges through which condensate drains. Between ridges the film is thinned out by centrifugal action thus giving less resistance due to heat conduction. Also turbulence due to drop and ridge formation may have significant effect.

Results obtained under dropwise condensation at varying heat flux show a considerable scatter, but may indicate lack of variation of h_s with heat flux. At rotational surfaces and dropwise condensation a decrease of U and h_s with rotational speed was obtained. This is probably due to reduction in size of drops and to the tendency for drops to be flung off the surface without contributing to the generation of bare metal surface as a rolling drop does.

Authors conclude dropwise condensation promotors can lead to improved performance in certain types of marine evaporators and condensers; also in equipment operating at low heat flux.

G. Selin, Sweden

4837. Leczfalvy, S., Evaporation from groundwater (in Hungarian), *Hidrologiai Kozlony* **39,** 4, 279–284, Aug. 1959.

Evaporation from groundwater, excluding transpiration, is investigated. Experiments into the determination of evaporation from sandy gravels suggested the following relationship

$$P = \frac{0.000175}{m} T^{1.43}$$

where

P = evaporation from groundwater, mm/hour

m = depth of the groundwater table below the terrain, in m

T = temperature prevailing at the soil surface, Centigrades.

The formula remains valid as long as $T < 21°C$ and the groundwater table is deeper than 40 cm below the terrain.

The effect of several physical factors was investigated experimentally, and it could be concluded that investigations into the temperature of the soil are significant as far as evaporation is concerned. Thus e.g. the molecularly bonded water content of the soil above the groundwater table is also of influence on evaporation from the groundwater.

Under climatological conditions prevailing in Hungary the curve of annual evaporation from sandy gravel soils can be described by the expression

$$P_{annual} = \frac{51.5}{m}$$

(P_{annual} is the annual evaporation from the groundwater in mm, and M is the depth of the groundwater table below the terrain in m.) The above formula loses its validity as soon as the groundwater table rises to within 10 cm of the terrain.

From author's summary

4838. Lapin, A., and Schurig, W. F., Heat transfer coefficients for finned exchangers, *Indust. Engng. Chem.* **51,** 8, 941–944, Aug. 1959.

Coefficients for a single type of finned tube heat-transfer coil were obtained. Results show random pattern as depth of tube rows is changed. Mass flow rates for air at atmospheric pressure and about ambient temperature, ranged from 1000 lb/(hr ft²) to 4000, based on minimum flow area. Coefficients increased from 4.5 to 9.0 Btu/(hr ft² F) with increasing flow rate for single coil; from 2.8 to 12 for eight-row coil. Surface used was 5/8-in. o d tubing with 8 radial fins/in. of 1.5 in. o d × 0.018 in. crimped copper fins.

Reviewer considers range of test conditions and tube configurations too narrow to justify presentation of correlations solely on authors's results. To be meaningful there should be comparison in graphical or analytical form with experiments of others.

D. Aronson, USA

4839. Krapivin, A. M., Investigation of operating cycle of steam-jet heat exchangers (in Russian), *Trudi Dnepropetr. In-ta Inzh. Zh.- d. Transp.* no. 26, 74-95, 1958; *Ref. Zh. Mekh.* no. 2, 1959, Rev. 1593.

The theory of the process given in the title is explained. The equations of gas dynamics, describing the process of expansion in the jet, the flow of the two-phase flow in the mixing chamber and compression in the diffuser (while taking into account the possibility of a direct shock of compression beyond the neck of the diffuser) are recorded. An experimental investigation is carried out of a steam-jet heat exchanger with different geometrical designs for the section between inlet and outlet valve through which steam passes, for the injection coefficient, for the counter-pressure beyond the diffuser, and so forth. The following basic conclusions were reached as the result of this investigation. (1) With determined coefficients of injection and rarefaction in the mixing chamber of the heat exchanger it was established that a

stable vapor-water emulsion is formed in which the vapor phase condenses and disappears only when influenced by an increase of pressure due to a jump in compression. When pressure is operating in the mixing chamber almost complete condensation of the steam is possible up to the time of the mixture's entry into the diffuser constriction. In this case the flow's velocity will remain transonic and the pressure jump will not take place, while in the diffuser a simple surge of water will take place. (2) The length of the mixing chamber has an effect on the state of the flow before its entry into the diffuser constriction and should not be less than 6 to 8 times the diameter of the working jet. The area of the annular section for the water inlet into the mixing chamber should be chosen while bearing in mind that the velocity of ejected water in this section should not exceed 3 m/sec. (3) When a jump of compression takes place in the diffuser constriction the counterpressure beyond the diffuser reaches its maximum, while the losses due to the jump can be evaluated in accordance with the k.p.d. (efficiency) of the diffuser, the figure obtained being 0.75 to 0.8.

V. Kh. Abiants

Courtesy Referativnyi Zhurnal, USSR

4840. Sunderland, J. E., and Grosh, R. J., A tabulation of the function $\exp X^2 \operatorname{erfc} X$, *ASME Trans.* **82**C (*J. Heat Transfer*), 1, 75–76 (Technical Briefs), Feb. 1960.

Authors report a tabulation of the function for values of the argument running from 0.10 to 7.00 in increments of 0.01. The values are given to four, five or six significant figures with an error of plus or minus one in the last figure. For values less than 0.10 or greater than 7.00, mathematical expressions are given for the function. Tabulation of the function may be obtained from the American Documentation Institute.

Reviewer believes that note fills a need in the literature for convenient and accurate tabulation of this function frequently appearing in problems of transient heat-conduction and diffusion problems, although no original information (per authors' statement) is provided.

H. Hurwicz, USA

4841. Jacobs, J. M., Heat transfer and fluid flow, A bibliography of selected report literature, U. S. Atomic Energy Commission TID–3305 (Supplement 1), 423 pp., June 1958.

A total of 2519 annotated references to the unclassified report literature is presented. Subjects covered under heat transfer and fluid flow include radioinduced heating; boiling; boiler, evaporators, pump, and heat exchanger design; hydrodynamics; coolants and their properties; thermal and flow instrumentation; high-temperature materials; thermal properties of materials; and thermal insulation. Subjects covered less completely include thermodynamics; aerodynamics; high-temperature corrosion; corrosion specific to heat-transfer systems; erosion; mass transfer; corrosion film formation and effects; coolant processing and radioactivity; radiation effects of heat-transfer materials; and pertinent data of thermonuclear processes. Subject, report number availability, and author indexes are given.

From author's summary

Combustion

(See also Revs. 4686, 4811, 4905)

4842. Hirschfelder, J. O., and Van Domelen, Sarah S., The propagation of flames supported by a zeroeth order chemical reaction, Univ. Wisconsin, Theoretical Chem. Lab. CM–964, 28 pp., Nov. 1959.

Exact solutions are presented of the single differential equation representing laminar flame propagation in a gas in which the volumetric reaction rate is an Arrhenius function of temperature but is independent of composition. Eight values of dimensionless activation energy are considered. The eigenvalues are compared with approximate values calculated by a method similar to those of Adams, von Karman-Penner, Wilde and Spalding; in the present case the square of the dimensionless mass flux of combustible is taken to be a quadratic function of the dimensionless temperature.

D. B. Spalding, England

4843. Stumke, H., Approximate determination of the average fields of state in plane or circular turbulent diffusion flames and dissociating free jets (in German), Jahrbuch Wissenschaft. Gesellsch. Luftfahrt, 1957, 381–401.

Author investigates theoretically the problem of a turbulent free gas jet with chemical reaction. On the basis of Prandtl's generalized momentum-transport theory and the conservation laws of mass and energy, equations are derived which allow the calculation of the time average of the fields of state (e.g. field of velocity, temperature, density), assuming a constant pressure in the whole region. Velocity of chemical reaction in the turbulent mixing zone is supposed to be proportional to the departure of the equilibrium composition.

Author deals with the problem most generally and abstractly (especially with regard to the chemical reaction). Reviewer would have expected an example with a simple chemical reaction actually calculated by the author.

C. Franze, Germany

4844. Berlad, A. L., and Yang, C. H., On the existence of steady state flames, *Combustion and Flame* **3**, 4, 447–452, Dec. 1959.

Examination of the adiabatic flame theories shows that the conditions, "adiabatic" and "steady-state," imposed on the flame model are contradictory when a realistic reaction rate law is used. For the case of a *freely propagating* flame, only a quasi-steady state can be achieved, even though the "adiabatic" condition is removed.

From authors' summary

4845. Menkes, J., On the stability of a plane deflagration wave, *Proc. Roy. Soc. Lond. (A)* **253**, 1274, 380–389, Dec. 1959.

Stability of a one-dimensional deflagration wave subjected to small disturbances was investigated analytically. Chemical kinetics, heat conduction and diffusion were considered. An arbitrary steady-state temperature distribution in the wave was used and the Lewis number was assumed to be unity.

Author concludes that, within the framework of his analysis, the wave is stable with respect to disturbances of all frequencies with the possible exception of zero frequency.

T. Y. Toong, USA

4846. Anagnostou, Evelyn, and Potter, A. E., Jr., Quenching diameters of some fast flames at low pressures, *Combustion and Flame* **3**, 4, 453–457, Dec. 1959.

Quenching diameters as a function of pressure have been presented for some fast stoichiometric hydrocarbon-oxygen and hydrogen-oxygen flames. The order of increasing ease of quenching is acetylene, ethylene, hydrogen, propane. The over-all reaction orders for all flames have been found to be very close to two.

From authors' summary

4847. Grumer, J., Cook, E. B., and Kubala, T. A., Considerations pertaining to spherical-vessel combustion, *Combustion and Flame* **3**, 4, 437–446, Dec. 1959.

Paper treats certain considerations bearing on the interpretation of measured flame speed and pressure rise rates during combustion in a spherical chamber.

The relation between the pressure rise and the fraction of the charge burnt as the wave traverses the vessel is involved in the evaluation of laminar burning velocity. New considerations are presented which show that using an alteration of Flamm and

Mache's equation for the fraction burned gives less error under the conditions of measurement.

An experimental technique has been developed to determine approximate empirical values of the expansion ratios for gases passing through a laminar combustion wave.

New data have been obtained over a range of subatmospheric and supra-atmospheric pressures to show that the pressure dependence of the burning velocity can be positive. However, a previous correlation of pressure exponents with only the burning velocity was found to be an oversimplification of the situation.

Observations were made of peak pressures and end pressures after cooling resulting from the combustion of very rich hydrogen-air mixtures at initial pressures of a half to three atmospheres. Observed values were within a few per cent of theoretical values based on assumed thermochemical equilibrium in the burnt gas.

A. S. Andes, USA

4848. Wood, B. J., Wise, H., and Inami, S. H., Heterogeneous combustion of multicomponent fuels, NASA TN D-206, 32 pp., Nov. 1959.

Authors investigate the problem of combustion of a "fuel drop containing liquid constituents of different physical and chemical properties." Experimental results obtained with a photoelectric shadowgraph apparatus indicate "that during combustion the composition of a multicomponent fuel drop changes by a process of simple batch distillation." Therefore, in the remaining liquid phase the concentration of the high boiling constituents increases. The stability of the drop during the combustion was found "to be a function of the initial drop size, the nature and relative quantities of the components in the liquid phase, and the magnitude of the differences in their boiling points."

Burning-rate coefficients for a group of binary fuel mixtures are given, also "burning characteristics of drops of hydrocarbon fuels, containing up to five constituents," including kerosene and jet fuel JP-4.

G. B. Siegmund, Germany

4849. Bloomer, H. E., Renas, P. E., and Antl, R. J., Experimental investigation in an altitude test facility of burning of excess combustibles in a rocket engine exhaust, NASA TN D-200, 25 pp., Jan. 1960.

An investigation was made in an altitude test chamber to determine methods of burning the excess fuel in the exhaust of a rocket engine which used JP-4 fuel and gaseous oxygen as propellants. Four afterburning configurations using bypass air as the oxidant and one using gaseous oxygen were tried. Gas samples were obtained from the rocket exhaust over the following range of variables: altitude pressure, 1 to 10 pounds per square inch; and rocket oxidant-fuel ratio, 1.80 to 3.20. Results of the investigation show that combustibles can be burned so that the products are nonflammable, over the range of variables covered, within a length of 38 rocket nozzle exit diameters.

From authors' summary

Book—4850. Taylor, J., Solid propellent and exothermic compositions, New York, Interscience Publishers, Inc., 1959, vii + 153 pp. $4.25.

The author has devoted his professional life to the explosives industry as a member of the Nobel Division of the Imperial Chemical Industries.

The book presented here deals with the use of chemicals as a source of energy, especially in connection with explosives and rocket propulsion.

The contents of this book go from gunpowder and pyrotechnics to explosives and propellants, the low-temperature gas-producing reactions based on nitrites and the hydrox blasting device to rocket motors and solid charges for rockets and propulsion, ending with a chapter on power cartridges and another one on gasless reactions.

The material treated is largely derived from work carried out in the laboratories of the I.C.I. It has been carefully selected and is clearly presented. Unfortunately for such an up-to-date topic we will in some cases feel the lack of fundamental scientific treatments, although the author seems aware of it. Since in many cases secret or classified material is not available for publication, the contents may appear in some parts unwillingly uneven or restricted.

Specialists of explosives and propellants will no doubt find in it useful data. A minor detail however appears regrettable to the reviewer: the spelling of the word propellant, which is randomly spelled with an *a* and with an *e*, the former being correct and generally applied.

P. Laffitte, France

4851. Rosen, G., Burning rates of solid propellants, *J. Chem. Phys.* **32,** 1, 89-93, Jan. 1960.

A mathematical model for steady-state combustion of a homogeneous solid propellant is developed. Rate of gasification is taken to be an Arrhenius function of surface temperature. Gasification is followed by gaseous combustion obeying second-order kinetics, with surface temperature being determined by balance of heat flows from gaseous flame to surface and from surface to interior of solid. An implicit equation for burning rate is obtained, graphical plots of burning rate versus pressure and kinetic parameters being presented for the special case where the heat of sublimation is small. The slope of the burning rate versus pressure curve is found to vary monotonically from a limit of unity at low pressure to a limit of zero at high pressure. This behavior is easily seen to be a necessary consequence of the model. Author believes that this model, which ignores the mixing process, may nevertheless be applicable to composite propellants containing ammonium perchlorate and organic binder. He suggests further burning-rate measurements at very high pressures.

R. Friedman, USA

4852. Marklund, T., and Lake, A., Experimental investigation of propellant erosion, *ARS J.* **30,** 2, 173-178, Feb. 1960.

Erosion test methods, characterized by separate gas-producing charges and separate specimens in the gas stream, are described. The specimens have been tablets, strips and nozzle inserts of composite propellants. Changing the temperature of the gas stream over a propellant specimen from 1690 to 2550 K did not seem to influence the erosion at constant gas velocity and pressure. Erosion on tablets of ϕ 1.4 cm was about 40 per cent higher than on strips, at a distance of 7.0 cm from the front edge for a certain propellant. Erosion at near sound velocity in a propellant nozzle was found to be of the same order of magnitude as on strips at lower gas velocity but the same mass velocity. Results are discussed particularly in view of the Lenoir and Robillard theory of propellant erosion. The strip method especially seems to be a useful tool for studies of the temperature resistance of materials for thermal insulation of rocket motors, nozzle inserts, etc.

From authors' summary

4853. Moutet, A., Veret, C., and Nadaud, L., Optical method for the instantaneous measurement of flame temperature (in French), *Rech. Aéro.* no. 68, 9-19, Jan./Feb. 1959.

Paper discusses apparatus based on modified Kurlbaum method for recording automatically the brightness temperature, true temperature and emissivity of small flames (in most cases, not exceeding 8-in. diameter). The method involves three measurements of monochromatic radiation: (a) from a standard source (filament lamp), (b) from the flame alone, and (c) from the lamp viewed through the flame. The first of these can be maintained constant and measured at the beginning of the experiment. Readings of the other two are recorded simultaneously; if necessary the calculations to enable temperature, etc., to be recorded directly can be

carried out on a computer. Two optical systems are described, one using a normal monochromatic prism and the other an interference filter. The latter modification allows a higher luminosity at the receiver—particularly useful when studying flames of low emissivity. The speed of response of these instruments is very high (10^{-3}_{s}).

Examples are given of the use of the apparatus in studying burning powders and liquids and in standardizing suction pyrometers. These illustrate the value of being able to measure the true temperature fluctuations in a flame (in one example ±50°C at 58 cycles/second) even when determining a mean value over a long time interval. Paper is quite detailed and well worth study by people interested in flames of this size.

G. G. Thurlow, England

4854. Vlasov, K. P., Connection between the flame temperature measured by optical means and by other methods, *ARS J.* **30,** 1, 83–85 (Russian Supplement), Jan. 1960. (Translation of *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk, Energetika i Avtomatika* no. 3, 100–103, 1959.)

A theoretical relationship between average optical temperature and mean thermodynamic temperature is obtained for a turbulent flame. Results from this development are compared with experimental data. Infrared pyrometry is stated to be superior to line-reversal techniques for determination of thermodynamic temperature. The effect of mixture inhomogeneity on optical temperature measurements is analyzed. Author states that this effect is within instrumental error of infrared pyrometer, but that line-reversal techniques resolve it. Simultaneous effects of turbulence and inhomogeneity upon optical temperature measurements are not treated.

Unfortunately, some misprints appear in the equations, and the caption information accompanying the figures seems to be presented rather obscurely. A. Q. Eschenroeder, USA

Prime Movers and Propulsion Devices

(See Revs. 4751, 4752, 4763, 4813, 4829, 4849, 4850, 4852, 4873)

Magneto-fluid-dynamics

(See also Revs. 4902, 4905)

4855. von Karman, T., Magnetofluidmechanics—Some comments in memory of D. Banki (in English), *Acta Techn., Acad. Sci. Hungaricae* **27,** 1/2, 41–51, 1959.

4856. Thompson, W. B., The physical basis of magnetohydrodynamics, Advances in Aeronautical Sciences, Vol. 2 (Proc. of the First International Congress in the Aeronautical Sciences, Madrid, Sept. 8–13, 1958), Pergamon Press, 1959, 1098–1110.

4857. Kochina, N. N., Shape-preserving, exact solution of the equations of magnetohydrodynamics, *Soviet Phys.-Doklady* **4,** 3, 521–525, Dec. 1959. (Translation of *Dokladi Akad. Nauk SSSR (N.S.)* **126,** 3, 528–531, May/June 1959 by Amer. Inst. Phys., Inc., New York, N. Y.)

Author considers one-dimensional, unsteady motion of an ideal electrically conducting gas in presence of magnetic field; a particular shape-preserving solution for the case of planar symmetry and one for the case of planar or axial symmetry are given. The conditions at the shock-wave front and the equation of a line of weak disturbance are written for both cases. More complicated solutions of the form of the foregoing are considered and analogy with the case in which the magnetic field is absent is examined.

R. Nardini, Italy

4858. Lyubimov, G. A., Stationary flow of an ideally conducting gas around a corner, *Soviet Phys.-Doklady* **4,** 3, 529–531, Dec. 1959. (Translation of *Dokladi Akad. Nauk SSSR (N.S.)* **126,** 4, 733–735, May/June 1959 by Amer. Inst. Phys., Inc., New York, N. Y.)

The problem of the flow as in the title is investigated for an arbitrary external magnetic-field distribution relative to the flow. A system of cylindrical coordinates is introduced in which the axis is directed along the edge of the corner, and following particular solutions depending only on the azimuthal angle φ are considered: (1) two progressive flows parallel to the plane $\varphi = \varphi_0$; (2) a solution which may be termed a Prandtl-Meyer rotational wave: density is constant, velocity and magnetic field change direction; (3) flow around an infinitely conducting corner: all unknown quantities are expressed as functions of the density, which may be determined numerically from a complicated differential equation; (4) flow around a nonconducting corner: the corresponding differential equations must apparently be integrated numerically. R. Nardini, Italy

4859. Nochevkina, I. I., On the approximation method in investigation of plane rotational flow in magnetohydrodynamics, *Soviet Phys.-Doklady* **4,** 3, 549–553, Dec. 1959. (Translation of *Dokladi Akad. Nauk SSSR (N.S.)* **126,** 6, 1220–1224, May/June 1959 by Amer. Inst. Phys., Inc., New York, N. Y.)

Equations are transformed to a form which corresponds to the usual gasdynamic case without magnetic fields but with a different equation of state. The latter is simplified in a specific Mach number range (example given was for the range $1.56 \leqslant M \leqslant 1.9$) to yield a separable differential equation.

H. Yoshihara, USA

4860. Meecham, W. C., Some exact solutions of the Navier-Stokes and the hydromagnetic equations, *Physics of Fluids* **2,** 2, 121–124, Mar.–Apr. 1959.

Author presents several exact, closed-form solutions to the basic equations of two-dimensional, incompressible magnetohydrodynamics in a medium of high electrical conductivity. Solutions are first presented for case of zero magnetic field (Navier-Stokes equations). Special forcing function is used, such that nonlinear inertial term and pressure term cancel out, leaving linear system.

Similar solutions applied to hydromagnetic equations result in decoupled velocity and magnetic fields; velocity fields follow applied force as before, and magnetic fields decay with Joule heating. Time behavior is quite general.

F. L. Wattendorf, USA

4861. Hains, F. D., Some exact solutions to the magnetohydrodynamic equations for incompressible flow, *J. Aero/Space Sci.* **26,** 4, 246–247 (Readers' Forum), Apr. 1959.

Steady-state two-dimensional nonviscous magnetohydrodynamical flow is described. The field lines are parabolic.

W. M. Elsasser, USA

4862. Kahalas, S. L., and Kashian, H. C., On the approach of electrons to equilibrium, *Physics of Fluids* **2,** 2, 100–102, Mar.–Apr. 1959.

For the case of slightly ionized gas, author considers relaxation to equilibrium of electrons having initially nonequilibrium velocity distribution. Assumptions are: gas consists of electrons and neutral molecules having Maxwellian interaction; major effect

is due to electron-molecule elastic encounters; electron-electron encounters are negligible; spatial diffusion is negligible.

Author computes change of electronic distribution function with time until Maxwellian distribution is reached. Author also shows how specific cases may be treated when electrons attach to neutral molecules, forming negative ions.

F. L. Wattendorf, USA

4863. Bernstein, I. B., and Rabinowitz, I. N., Theory of electrostatic probes in a low-density plasma, *Physics of Fluids* **2,** 2, 112–121, Mar.–Apr. 1959.

Author presents computational method for electrostatic probes in low-density plasmas where collisions are negligible. Particular application is made to collection of positive ions by spherical and cylindrical probes. Boltzmann equation gives particle density and flux as functionals of electrostatic potential and absorptive characteristics of probe. Potential is determined by Poisson's equation.

Numerical computations are given for collection of monoenergetic ions, assuming negligible electron current. Results show influence of ion temperature on potential, and possibility of trapped ions for sufficiently small probe radii, which could affect local potential. F. L. Wattendorf, USA

4864. Yih, C.-S., Inhibition of hydrodynamic instability by an electric current, *Physics of Fluids* **2,** 2, 125–130, Mar.–Apr. 1959.

Paper presents analytical treatment of hydrodynamic instability in vertical cylinder of viscous fluid heated from below with temperature decreasing linearly with height. Objective is to show great difference in effectiveness of circular magnetic fields on inhibiting different modes of instability. Results indicate that longitudinal electric currents have strong inhibiting effects on unsymmetrical modes of convection, but no effect on axisymmetrical modes. Author points out interesting situations at Rayleigh number 452.1 (critical for axisymmetric convection). For electric currents greater than critical value required to inhibit unsymmetric convection, only axisymmetric convection can occur, whereas for currents less than critical the first mode of unsymmetric convection prevails. F. L. Wattendorf USA

4865. Zhigulev, V. N., On a class of motion in magnetohydrodynamics, *Appl. Math. Mech. (Prikl. Mat. Mekh.)* **22,** 3, 537–539, 1958. (Pergamon Press, Inc., 122 E. 55th St., New York 22, N. Y.)

The equations of magneto-gasdynamics for an ideal plasma (inviscid, non-heat-conducting and infinitely electrical conducting) have been discussed under the condition that the vectors of magnetic field and of velocity do not change along lines of magnetic force.

Under these conditions, the equations of magneto-gasdynamics are reduced essentially the same as those of ordinary gasdynamics but the gas pressure is replaced by the sum of gas pressure and magnetic pressure. All the known methods in ordinary gasdynamics may be used to solve this class of flows in magneto-gasdynamics. S. I. Pai, USA

4866. Pikel'ner, S. B., Structure of a magnetohydrodynamic shock wave in a partially ionized gas, *Soviet Phys.-JETP* **9,** 5, 1089–1093, Nov. 1959. (Translation from *Zh. Eksp. Teor. Fiz., Akad. Nauk SSSR* **36,** 1536–1541, May 1959 by Amer. Inst. Phys., Inc., New York, N. Y.)

Author argues that "piston"-induced plane wave, propagating perpendicular to an originally uniform magnetic field in a partially ionized gas, will consist of a thin plasma shock front followed by a relaxation zone in which the neutral particle velocities adjust to the new equilibrium value. It is this relaxation region only which is investigated. Principal assumptions are that plasma shock induces no further ionization and that thermal velocities are small compared with wave speed. Also, ion/neutral particle interactions are treated on simple rigid sphere kinetic theory basis and author uses same basis to argue that presence of charge-exchange will roughly halve the relaxation length.

J. F. Clarke, England

4867. Kiselev, M. I., On the calculation of shock waves in magnetohydrodynamics, *Soviet Phys.-Doklady* **4,** 3, 517–520, Dec. 1959. (Translation of *Dokladi Akad. Nauk SSSR (N.S.)* **126,** 3, 524–527, May/June 1959 by Amer. Inst. Phys., Inc., New York, N. Y.)

Knowledge of a root of the Rankine-Hugoniot algebraic equations is used to simplify the calculations for both normal and oblique shocks with arbitrary orientation of the magnetic field.

H. Yoshihara, USA

4868. Hart, P. J., Effect of gas pressure and cone angle on the velocities of electrically excited shock waves, *J. Appl. Phys.* **31,** 2, 436–437 (Letters to the Editor), Feb. 1960.

4869. Rott, N., A simple construction for the determination of the magnetohydrodynamic wave speed in a compressible conductor, *J. Aero/Space Sci.* **26,** 4, 249–250 (Readers' Forum), Apr. 1959.

Geometrical construction is given for the solution of the characteristic equation of plane waves in subsonic motion at an angle with the field direction. W. M. Elsasser, USA

4870. Steketee, J. A., The oscillating plate in magnetohydrodynamics, Univ. Toronto, Inst. Aerophys. Rep. 63, 36 pp., Aug. 1959.

Paper considers harmonic oscillations of a flat plate parallel to itself when it is immersed in a slightly viscous conducting field in presence of a normal magnetic field. Both a magnetic and a viscous boundary layer are seen to arise whose thickness is inversely proportional to the inverse square roots of the respective Reynolds numbers. L. Trilling, USA

4871. Dawson, J., and Oberman, C., Oscillations of a finite cold plasma in a strong magnetic field, *Physics of Fluids* **2,** 2, 103–111, Mar.–Apr. 1959.

Author considers oscillations of bounded cold plasma in strong external magnetic field. Two plasma geometries are treated: infinite slab and cylinder. Constraining magnetic field is parallel to surface. Simplifying assumptions: Motions perpendicular to magnetic fields are neglected; small amplitude of oscillations permits use of linearized equations; thermal motions of electrons are negligible. Normal modes of oscillations are derived for both slab and cylinder. Special problems considered are: reflection and transmission properties of slab; scattering from cylinder; forced oscillations and penetration of impressed electric field into plasma; radiation from plasma oscillations.

F. L. Wattendorf, USA

4872. Boynton, J. H., Experimental study of an ablating sphere with hydromagnetic effect included, *J. Aero/Space Sci.* **27,** 4, 306–307 (Readers' Forum), Apr. 1960.

4873. Sporn, P., and Kantrowitz, A., Magnetohydrodynamics—future power process? *Power* **103,** 11, 62–65, Nov. 1959.

Article discusses briefly various methods for direct conversion of thermal energy to electrical energy for power applications. The developments in thermoelectric generation, thermionic generation and magnetohydrodynamic generation are briefly compared with power production by means of fission processes and steam turbogenerators. The magnetohydrodynamic generator system is explored nontechnically in terms of anticipated economic advantage and feasibility. Major problem areas in the path of rapid technical

exploitation are outlined. The article suggests that there will exist in the future a concerted effort by the utility companies to exploit the magnetohydrodynamic generation system.

R. M. Drake, Jr., USA

Aeroelasticity

4874. Kussner, H. G., Aeroelastic problems of aircraft construction, Advances in Aeronautical Sciences, Vol. 2 (Proc. of the First International Congress in the Aeronautical Sciences, Madrid, Sept. 8–13, 1958), Pergamon Press, 1959, 709–722.

4875. Zisfein, M. B., and Frueh, F. J., A study of velocity-frequency-damping relationships for wing and panel binary systems in high supersonic flow, AFOSR TN 59-969 (Bell Aircraft Corp. Rep. 9015-19-001), 55 pp., Oct. 1959.

Results of flutter calculations are usually presented in (V, g)-diagrams which show the amount of structural damping required to make oscillations just harmonic at a certain speed. Occasionally it occurs that an increase of structural damping decreases the flutter speed, which is shown by a "loopback" in the curve. This phenomenon is investigated by authors as well as the problem whether it is possible to deduce flutter severity from the slope of the curve in the (V, g)-diagram.

For this purpose a pitch-plunge wing and a panel with two admitted modes are considered in supersonic flow, the aerodynamic forces being taken from piston theory. For these systems not only the structural damping but also the viscous damping ζ required to give harmonic oscillations is calculated, while moreover decay constants γ of the response are evaluated as functions of the velocity. It is shown that loopbacks can also occur in (V, ζ)-diagrams although less frequently then in (V, g)-diagrams, while they are impossible in (V, γ)-diagrams. There is no simple relation between (V, γ)- and (V, g)-diagrams besides their yielding the same flutter point. The importance of (V, ω)-diagrams, where ω is frequency, for the detection of loopbacks is demonstrated.

A. I. van de Vooren, Holland

4876. Salaun, P., Structural damping matrix in flutter calculations (in French), *ONERA Pub.* **69,** 43–48, Mar./Apr. 1959.

A two-degrees-of-freedom vibrating system is assumed to be elastic and viscously damped. Having established the equation of motion in terms of generalized matrices of inertias, dampings, rigidities and the column matrix of the space-time variables, author studies the stability of the vibrating system in terms of functions which are the direct and cross terms in the damping matrix. The application to an aeroelastic system is outlined and a numerical example worked out. Author concludes that in a two-degrees-of-freedom vibrating system, associated with an energy reservoir, the internal viscous damping can have an influence on instability. Its effect becomes particularly marked for a system involving coupling terms. The structural damping, often neglected in flutter calculations, should therefore be considered. The damping terms become important when one of the modes involves rotation such as a wing-aileron system.

D. H. Cheng, USA

4877. Widmayer, E., Jr., Lauten, W. T., Jr., and Clevenson, S. A., Experimental investigation of the effect of aspect ratio and Mach number on the flutter of cantilever wings, NASA TN D-229, 20 pp., Apr. 1960.

Models having aspect ratios ranging from 2 to 13 were tested at Mach numbers up to 0.92. No general attempt is made to correlate the data with three-dimensional-flow theory, but an examination of the data is made on the basis of reference theoretical values obtained from the two-dimensional incompressible-flow theory. On this basis a reduction in aspect ratio, in general, increased the ratio of the experimental flutter speed to the calculated flutter speed. The analysis also indicated that, for a given aspect ratio, the flutter-speed ratio decreased slightly as the Mach number was increased.

From authors' summary

4878. Johns, D. J., The influence of panel deformations on wing flutter, *J. Aero/Space Sci.* **27,** 2, 137–138 (Readers' Forum), Feb. 1960.

4879. Johnson, W. H., An electrodynamic method of exciting servo-tabs for flight flutter testing, Aero. Res. Counc. Lond. Curr. Pap. 466, 14 pp., 1960.

A detailed description is given of an electrodynamic method of exciting servo-tabs for flight flutter testing. Tests made to develop and establish the feasibility of the technique on a large aircraft with pure servo-tab controls are described. Some specimen flight records are shown.

It is considered that the system is useful for investigating tab flutter characteristics up to about 30 cycles per second, but that its main value lies in the excitation of aircraft structure modes at very low frequencies (below 3 cps) where it possesses a marked superiority over the mechanical inertia exciter.

From author's summary

4880. Schaffer, A. P., Flight dynamics of large external stores, *Aero/Space Engng.* **19,** 2, 39–44, Feb. 1960.

An application of flight flutter investigational experiences as a guide to the preliminary design and flight testing of relatively large external stores is considered. The presentation is based upon results of the external stores flight flutter investigation. The program was performed with instrumented test vehicles in a variety of aircraft and store configurations. The information is intended to summarize the salient features of a wing/store flight flutter evaluation.

From author's summary

4881. Sewall, J. L., Herr, R. W., and Igoe, W. B., Flutter investigation of a true-speed dynamic model with various tip-tank configurations, NASA TN D-178, 80 pp., Mar. 1960.

A 1/6-scale wing tip-tank model, representative of an unswept-wing fighter airplane, was flutter tested in the Langley 16-foot transonic tunnel. The wing was of spar-balsa segment-type construction and was dynamically scaled to flutter at the same speed as a typical full-scale configuration. Each tip tank housed a device for arresting flutter by providing for a quick shift in the tip-tank center of gravity; this device proved to be very effective in stopping symmetric flutter when the tip-tank center of gravity was shifted forward of the wing elastic axis. Experimental flutter results indicating the effects of external stores are compared with the results of a conventional Rayleigh-Ritz type of flutter analysis which predicted flutter speeds that were excessively conservative with respect to experiment as the tip-tank center of gravity approached the elastic axis.

From authors' summary

4882. Sutton, F. B., and Brownson, J. J., The effects of thrust reversal at Mach numbers up to 0.86 on the longitudinal and buffeting characteristics of a typical jet-transport airplane configuration, NASA TN D-136, 93 pp., Mar. 1960.

The results of the investigation show that thrust reversal can be used as a very effective method of speed control for jet-transport airplanes making steep, relatively rapid descents from operational altitudes. Use of thrust reversers can more than double the cruise drag of such aircraft, and the test results show that at a constant Mach number of about 0.80 the initial rate of descent from cruising altitudes can be increased from about 5000 feet per minute to over 12,000 feet per minute. Thrust reversal had only small effects on the longitudinal stability and trim characteristics of the model at

the relatively low lift coefficients required for rapid descents by jet-transport aircraft. Operation of the reversers at a Mach number of 0.80 and an assumed initial altitude of 30,000 feet with complete tail-pipe blockage and the simulated power normally required for level flight resulted in a small stabilizing movement of the aerodynamic center corresponding to about 2% of the mean aerodynamic chord and about a $\pm 1^\circ$ change in the horizontal-tail angle required for trim.

Reverse thrust resulted in reductions in lift-curve slope and reduced the lift coefficients at which static-longitudinal instability occurred. However, these lift coefficients were usually higher than the lift coefficients of interest for reverser operation at high speeds.

The effects of thrust reversal on the buffeting characteristics of both the wing and tail of the model were small. At the relatively low lift coefficients associated with steep high-speed descents, these effects were negligible.

From authors' summary

4883. Johns, D. J., Inertia effects on some static aeroelastic problems, *J. Aero/Space Sci.* **27,** 3, 237–238 (Readers' Forum), Mar. 1960.

4884. Houbolt, J. C., On the response of structures having multiple random inputs (in English), Jahrbuch Wissenschaft. Gesellsch. Luftfahrt, 1957, 296–305.

The techniques of power spectral analysis applied to dynamic problems of aircraft involving random disturbances are considered. Cross spectra are introduced. These have the same relation to the correlation function of two different random functions as the power spectrum has to the autocorrelation function. These cross spectra are important in the problem of airplane gust encounter when variations of turbulence along the span are taken into account. The importance of these spanwise variations depend upon the turbulence scale, which at present is still an uncertain quantity. If it is small, spanwise effects become more important and they may either increase or decrease the loads obtained from an approach with uniform spanwise turbulence. In particular, they are increased in the case of spacial resonance, that is for those spanwise gust components of which the wavelength is approximately equal to the distance between nodes of the flexural mode.

A. I. van de Vooren, Holland

Aeronautics

(See Revs. 4729, 4730, 4744, 4779, 4791, 4818, 4918)

Astronautics

(See also Revs. 4442, 4445, 4447, 4768, 4829, 4942, 4943, 4944)

Book—4885. Finlay-Freundlich, E., Celestial mechanics, New York, Pergamon Press, Inc., 1958, viii + 150 pp. $7.50.

The launching of artificial earth satellites and space probes has sparked a surge of new interest in celestial mechanics. Not only astronomers, but mathematicians and engineers are delving into the intricacies of orbit determination and perturbation theory. Thus there is a need for a text which is self-contained and presents this material understandably for the non-astronomer.

The present text satisfies this need to a certain extent in that it is self-contained, and concisely develops the basic mathematical tools for celestial mechanics. However, it is a book written for astronomers, and designed for application to developments in modern astronomy. It hardly meets the needs of the student of rocket trajectories, nor does it recognize the place of machine computation in modern orbit determination techniques.

In the introductory chapter, conic section orbits and their properties are summarized. Chapter I formulates the equations for the n-body problem and discusses the three-body problem at some length, including several pages on the restricted three-body problem. Canonical transformations, the Hamilton-Jacobi equation, and the Delaunay variables are introduced in Chapter II. Chapter III is concerned with generalities on the theory of perturbations. The final chapters deal with problems in modern astronomy, including the application of the theory to the two-body problem for extended deformable bodies and to the motion of the apsidal line is relativistic mechanics.

J. Lorell, USA

Book—4886. Kurth, R., Introduction to the mechanics of the solar system, New York, Pergamon Press, Inc., 1959, ix + 177 pp. $6.50.

In this monograph the author presents a rigorous though simplified and uncluttered presentation of the subject matter, of great potential usefulness in dealing with mechanics of bodies reaching far out into interplanetary space. Author discusses thoroughly the mechanics of a single planet, the dynamics of the planetary system with special emphasis on perturbations; furthermore, a planet in its action as a solid body, not only as a particle.

Somewhat less of the vector treatment would be an asset, inasmuch as the latter tends to obscure the physics of the situation; the direct mathematical approach would greatly enhance the value of this treatise, without sacrificing anything of its high-level approach. The text is pleasantly readable, clear and concise, and in good balance with the inserted mathematics.

This monograph brings pure astronomical science within the range of applied science and occupies, as such, an unique place; it will be highly regarded as a source for study and reference in circles engaged in the rapidly expanding field of space technology.

J. Mandelker, USA

Book—4887. Beer, A., edited by, Vistas in astronomy, Vol. 3, New York, Pergamon Press, 1960, vii + 345 pp. $18.

Collection of papers on various phases on astronomy.

Ed.

4888. Trajectory problems in cislunar space, AFOSR TN 59-1284 (Westinghouse Elect. Corp., Air Arm Div. TN-3678, DYD-95008), 42 pp., Dec. 1959.

To investigate the effects of injection and midcourse errors on the conditions at arrival to the moon, the following trajectory was chosen: horizontal injection at 200-mi altitude with 0.9933 escape velocity resulting in a capture orbit around the moon at 3000-mi altitude with 3400-mph velocity. The calculation was based on the restricted three-body problem, which according to Michaels et al [*Astronautical Sciences Review*, Jan.-Mar. 1960] might be considerably less accurate than thought before.

The report presents three sets of charts to help feasibility studies in guidance requirements. The first set shows the effect of initial errors on the variation of the miss distance from the nominal 3000 mi and on the deviation from the nominal passing velocity of 3400 mph. The second set shows the effect of vectorial position errors at different points of the nominal trajectory on the above-defined conditions of arrival at the moon. Finally, the third set shows the result of applying impulse vectors at different points of the trajectory.

The surprising conclusion is that the effects of midcourse velocity correction on lunar miss distance and passing velocity are diametrically opposed; thus two impulses are required to correct both of these factors. No attempt was made to determine the optimum combinations of corrective impulses which, by the way, are strongly cross coupled.

G. S. Gedeon, USA

4889. Ross, S., Composite trajectories yielding maximum coasting apogee velocity, *ARS J.* **29,** 11, 843–848, Nov. 1959.

Expression is obtained that maximizes as a function of thrust direction velocity at apogee of coasting arc following second-stage burnout of two-stage rocket. Assumptions are: flat earth during second-stage burning; constant second-stage thrust; negligible aerodynamic effects after first-stage burnout. Sample calculation using Vanguard parameters is presented.

R. K. Sherburne, USA

4890. Hutcheson, J. H., Earth-period (24-hr) satellites, *ARS J.* **29,** 11, 849–853, Nov. 1959.

Near perfect 24-hour satellite orbits are considered. Small variations in period, values of inclination of orbital plane to 90°, changes in eccentricity, and perturbations due to Sun and Moon result in several types of ground tracks shown in figures. Motion relative to earth varies from nearly zero from equatorial orbit to hemispheric coverage for polar orbit. Communication and observation applications are discussed.

R. K. Sherburne, USA

4891. Tempelman, W., Comparison of minimum energy paths and apogee designation paths, *ARS J.* **29,** 11, 865–868 (Tech. Notes), Nov. 1959.

A comparison of minimum energy paths and apogee designation paths reveals that for distances greater than three times the injection distance there is little difference. Distances less than twice the injection distance reveal significant differences. For minimum energy paths, corresponding to each velocity there is a reachable envelope in space which constitutes an ellipse. Also, constant injection angles are found to be represented in space by straight lines, equally spaced, originating from the initial point.

From author's summary by R. K. Sherburne, USA

4892. Moeckel, W. E., Departure trajectories for interplanetary vehicles, NASA TN D–80, 35 pp., Nov. 1959.

General expressions are derived for the magnitude and direction of the launching velocity needed to reach another planet from any point on the Earth's surface. The effect of the inclination of the orbital plane of the destination planet is considered, as well as the effect of departure date and selected trajectory. A procedure is given for determining optimum time of day for launching from any latitude to obtain maximum benefit of the Earth's rotation. Results of the analysis are illustrated for typical Earth–Venus trajectories.

The analysis indicates that launching of interplanetary vehicles can take place from any latitude with velocity penalties no greater than loss of the benefit of the Earth's rotation. The best launching latitude is found to depend strongly on the trajectory to be followed and is not necessarily the equator. By proper selection of time of day, most of the benefit of the rotational component of the Earth at the launch latitude can be realized. Penalties associated with launching from satellite orbits can be much more severe, amounting to loss of the benefit of the orbital speed of the vehicle, if the orbit plane is improperly inclined.

From author's summary by A. Miele, USA

4893. Miele, A., and Cappellari, J. O., Jr., Approximate solutions to optimum climbing trajectory for a rocket-powered aircraft, NASA TN D–150, 56 pp., Sept. 1959.

The climbing program of a rocket-powered aircraft is analyzed with regard to minimum time trajectories. By using the indirect methods of the calculus of variations it is shown that, if the centripetal acceleration is neglected in the equations of motion, the totality of extremal arcs is composed of a number of constant path inclination subarcs plus one variable path inclination subarc. Under suitable hypotheses for the drag function, a solution in a closed form is obtained for the variable path inclination subarc.

For certain types of drag polars the variable path inclination subarc may split into several branches, one of which is subsonic, one transonic, and one supersonic. With regard to minimum time trajectories only the subsonic and the supersonic branch are of interest; the transition path from the former to the latter branch is studied and its optimum configuration analytically predicted.

The boundary-value problem is considered. Methods are developed for connecting the subarcs resulting from the Euler equations into the extremal arc minimizing the climbing time. The effect of important design parameters, such as wing loading or thrust loading, on the solutions is investigated.

From authors' summary

4894. Loh, W. H. T., Two simple equations for orbital mechanics, *ARS J.* **29,** 2, 146–147 (Tech. Notes), Feb. 1959.

Author remarks that many problems in orbital mechanics are solved more conveniently using the mathematical formulations of the laws of conservation of energy and of angular momentum rather than the differential equations of motion. This notion is substantiated through a number of examples.

H. F. Michielsen, USA

4895. Lukasiewicz, J., Experimental investigation of hypervelocity flight, Advances in Aeronautical Sciences, Vol. 1 (Proc. of the First International Congress in the Aeronautical Sciences, Madrid, Sept. 8–13, 1958), New York, Pergamon Press, 1959, 127–186.

Experimental techniques which are being developed for investigation of hypervelocity flight are considered in relation to characteristics of trajectories of interest. A distinction is made between hypersonic and hypervelocity test facilities. Problems associated with the design of air heaters and hypersonic wind-tunnel nozzles are discussed, with particular reference to axisymmetric nozzles. The performance and limitations of shock-tube tunnels, piston-compression tunnels, hotshot-type tunnels, aeroballistic ranges, and free flight are considered. The application of electric-arc method of heating air to drive wind tunnels (so-called hotshot type) and hypervelocity guns is discussed in some detail on the basis of experimental data available. The problems of simulating hypervelocity flight at low densities are discussed.

From author's summary

4896. Nidey, R. A., Gravitational torque on a satellite of arbitrary shape, *ARS J.* **30,** 2, 203–204 (Tech. Notes), Feb. 1960.

Expression is derived for the mean gravitational torque exerted on a rigid satellite with arbitrary mass distribution. The torque is assumed to be exerted by a fixed point-symmetric earth. The orbit is assumed to be circular and the attitude of the satellite in the orbit to be fixed. The magnitude of this mean torque is shown to be of the order of 10^{-6} ft-lb for satellites of the dimensions of those launched recently. Author expresses the opinion that the cumulative effects of this small torque cannot safely be ignored.

Since what is computed is part of the constraining torque necessary to preserve a fixed attitude, equations of motion do not enter. It is interesting to ask whether the variation of the gravitational torque with changes in the attitude of the satellite might not lead to an attitude stable in some sense. Earth's oldest satellite exhibits a degree of rotational stability which can only be regarded as a hallmark of truly professional design.

L. E. Goodman, USA

4897. Doolin, B. F., Gravity torque on an orbiting vehicle, NASA TN D–70, 45 pp., Sept. 1959.

Author analyzes the effect of gravity torques on the stability of a symmetric orbiting body. It is shown that if the small terms

arising due to the oblateness of the earth are neglected, an invariant property exists that greatly simplifies the problem of expressing the potential energy in terms of the moments and products of inertia about axes fixed in the body.

The chief contribution of this paper is in establishing a simplified method of analyzing the effect of gravity torques on the stability of orbiting vehicles in terms of the body coordinates.

T. K. Caughey, USA

4898. Fraeijs de Veubeke, B., The problem of maximum range in a uniform gravitational field (in French), *Astronaut. Acta* **4,** 1, 1–14, 1958.

4899. Westerman, H. R., Perturbation approach to the effect of the geomagnetic field on a charged satellite, *ARS J.* **30,** 2, 204–205 (Tech. Notes), Feb. 1960.

4900. Traenkle, C. A., Mechanics of the power and launching phase for missiles and satellites (in English), *Ing.-Arch.* **28,** 335–356, Mar. 1959.

Theoretical study of equations of motion of ballistic missiles and satellites during powered flight. Author first considers problem in absence of atmospheric effects to obtain first approximation to optimum flight path. Vertical launch is assumed in anticipation of limitations set by aerodynamic heating and drag. Numerical and graphical results are presented for a number of flights. Perturbations to the idealized trajectories are then included to account for lift and drag. The atmosphere is treated in terms of a characteristic height with cut off at 100,000 ft. Two-stage vehicles are considered for orbiting systems and criteria for optimization of payload on orbit. Author does not consider possiblity of multiple burning with coast phases in between.

In an age of vast electronic computers, it is refreshing to find a contribution to the subject of orbital mechanics in which all computations are done by hand. The author is to be complimented for developing simple iteration procedures and approximation rules which make hand computation possible.

W. C. Griffith, USA

4901. Coppa, A. P., Structural considerations of manned space vehicles, *ARS J.* **30,** 1, 34–40, Mar. 1960.

This paper considers the structural requirements for a manned space vehicle. It gives approaches leading to an optimum vehicle considering the requirements of thermodynamics and human factors, in addition to structures. The necessity of early and thorough integration of these different requirements is emphasized. Several space vehicle configurations are presented including a ballistic and a glide type, in order to exemplify some of the various structural problems encountered in each type during the phases of spaceflight, entry into an atmosphere and landing. These include aerodynamic heating and loading, meteoroid impact and other problems. Materials and constructions suitable for optimum space structures are discussed sufficiently to demonstrate available choices and indicate areas of required development.

From author's summary

4902. Reiffel, L., Structural damage and other effects of solar plasmas, *ARS J.* **30,** 3, 258–262, Mar. 1960.

For orbits or trajectories that carry large area lightweight structures outside of protected regions of space defined by planetary magnetic fields, the damaging effects of solar plasma streams are shown to be potentially serious and may result in low durability or high payload penalties. Estimates given depend directly on plasma stream densities and velocities which are only very approximately known. However a reduction by one order of magnitude or more in widely held current estimates of the properties of the solar plasma would still imply a considerable effect on particular structural materials. Substances used as thin coatings on more massive structures would be similarly affected.

From author's summary

4903. Konecci, E. G., Trapp, R. F., and Hunter, M. W., Manned nuclear space systems, Part 1, High-thrust nuclear systems; Part 2, Low-thrust nuclear systems, *Aero/Space Engng.* **19,** 1, 34–41, Jan. 1960; **19,** 2, 49–54, Feb. 1960.

4904. Gazley, C., Jr., Kellogg, W. W., and Vestine, E. H., Space vehicle environment, *J. Aero/Space Sci.* **26,** 12, 770–782, 814, Dec. 1959.

Ballistics, Explosions

(See also Revs. 4560, 4742, 4842, 4851, 4852, 4886)

4905. Lyubimov, G. A., The effect of an electromagnetic field on the detonation regime, *Soviet Phys.-Doklady* **4,** 3, 526–528, Dec. 1959. (Translation of *Doklady Akad. Nauk SSSR (N.S.)* **126,** 3, 532–534, May/June 1959 by Amer. Inst. Phys., Inc., New York, N. Y.)

The paper considers the modification to the usual laws governing detonation shocks caused by the presence of a magnetic field.

One of the author's results, which the reviewer found curious, is as follows:

Consider a nonconducting fluid whose motion in the absence of a magnetic field is free of detonation shocks. The author concludes that in certain circumstances the application of a magnetic field to the fluid can lead to detonation shocks in the field of flow.

K. Stewartson, England

4906. Adler, L. B., Hobaica, E. C., and Luker, J. A., The effect of external factors on the formation of detonation in saturated knallgas-steam mixtures, *Combustion and Flame* **3,** 4, 481–493, Dec. 1959.

The formation of detonation in saturated mixtures of knallgas and steam at 100 C was studied with respect to spark and hot-wire modes of ignition and geometry (diameter) of the reaction vessel. Reaction pressures and the amount of knallgas consumed by reaction in each experimental mixture were measured. The data indicate that the ease with which detonation is formed is affected by both of the primary variables in a dual manner which is strongly dependent upon heat and wall effects related to the reactor size. The controlling effects observed are apparently accentuated due to the "weak" nature of the pre-detonation reactions and the "slow" transition to detonation which are characteristic of the majority of saturated knallgas-steam mixtures.

From authors' summary

4907. Jacobs, S. J., Recent advances in condensed media detonations, *ARS J.* **30,** 2, 151–158, Feb. 1960.

4908. Belles, F. E., Detonability and chemical kinetics: Prediction of limits of detonability of hydrogen, Seventh Symposium (International) on Combustion, London and Oxford, August 28–September 3, 1958; New York, Academic Press, 1959, 745–751.

4909. Kapur, J. N., The internal ballistics of a supergun, *Appl. Scient. Res.* (*A*) **8,** 6, 393–402, 1959.

Author presents equations for gun with propellant charges distributed along barrel; charges begin burning after projectile passes. Method accounts for heat losses, bore friction, covolume corrections, and burning law. However, solution employs conventional approximations applicable at low velocity for pressure behind projectile and for propellant gas kinetic energy. Reviewer

notes that at high velocity more exact unsteady flow theory must be used. A. E. Seigel, USA

4910. Andriankin, E. I., Method of perturbation in the problem of a strong explosion (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 12, 3–14, Dec. 1958.

In the present paper a linearized method for the calculation of strong nonspherical explosion waves in a homogeneous and inhomogeneous atmosphere is developed. Asymptotic formulas are obtained for low values of the significant variable of the problem, and the conservation law leads to formulas connecting the intrinsic energy of the gas with the laws of propagation of the shock front. Special results are presented for an explosion wave propagating in an atmosphere with a density decreasing linearly with altitude.

W. Wuest, Germany

4911. Bioletti, C., and Cunningham, B. E., A high-velocity gun employing a shock-compressed light gas, NASA TN D-307, 19 pp., Feb. 1960.

A light gas gun is described which is relatively simple in construction and operation. Projectiles of 20-mm diameter are launched by helium which has been compressed and heated by a two-stage shock process. An explosion of powder is the source of energy. The unusual feature is a light piston which operates at supersonic speed in the second-stage shock tube. Muzzle velocities of over 20,000 feet per second are obtained with light projectiles. From authors' summary

4912. Sakharov, V. N., Kolesnikov-Svinarev, V. I., Nazarenko, V. A., and Zabidarov, E. I., Positional distribution of the soil ejected as a result of underground explosions, *Soviet Phys.-Doklady* **4,** 1, 186–189, Aug. 1959. (Translation of *Doklady Akad. Nauk SSSR (N.S.)* **124,** 2, 314–317, Jan./Feb. 1959 by Amer. Inst. Phys., Inc., New York, N. Y.)

Paper describes novel cratering experiments with H. E. charges of 10 kg to 100 metric tons weight exploded in loess and clay soils. Significant experimental data are presented on the phenomenology of explosive excavation.

Correlation is made between the pre-shot and post-shot location of pellets initially distributed at known positions throughout a cross section of the cratered zone. Pellets were numerically labeled for identification and radioactively tagged to facilitate post-shot location.

Paper describes trajectory end points for the pellets of uniform size, but neglects the significant effect of size of ejected particle on the distance of ejection. An empirical relation between amount of soil deposited and distance from the explosive epicenter, in terms of explosive weight and depth of charge, is inferred from the initial and final position of the pellets, rather than by direct measurement of soil deposited.

Interest in the subject is attested by the English language translation of the paper by at least three different groups. Other translations are "Local distribution of earth thrown up by underground explosion," *Physics Express* **1,** 1, 21–22, Apr. 1959; and "The local distribution of soil 'throw-out' from underground explosions," SCL-T-240 (Sandia Corporation Translation-Weinrich) Apr. 1, 1959, which is available in photostat or microfilm form from the Library of Congress.

Reviewer believes that, excepting three specific errors of translation, SCL-T-240 is the most communicative and contains the fewest flaws of semantic and technical importance. In that translation,

page 2, line nineteen, possibly should read "...using *slender* vertical *boles*.";

page 3, line thirteen, should read "...*above* the charge...;" and

page 8, line eight, should read "...for the *distribution of throw-out* may be...." R. P. Reed, USA

4913. Grigoryan, S. S., Sokolov, A. G., and Spasibukhov, Yu, I., On modeling the movement of a massive solid body under the influence of a shock wave, *Soviet Phys.-Doklady* **4,** 1, 74–76, Aug. 1959. (Translation of *Doklady Akad. Nauk SSSR (N.S.)* **124,** 1, 48–50, Jan./Feb. 1959 by Amer. Inst. Phys., Inc., New York, N. Y.)

Author treats problem of response of a rigid body to explosive waves, and derives rules for modeling certain restricted cases. Dimensional analysis has been used. Reviewer derived same dimensionless groups which appear in the first equation and form the basis for the remainder of the analysis. Several of the later equations were found to be difficult to duplicate, and the text is rather sketchy as to symbol definitions and assumptions.

Author briefly describes experiments involving the response of spheres to shock waves in a shock tube. Reviewer is impressed with statements regarding agreement between analytical and experimental approaches, but would prefer a more complete description of both. R. E. Goode, USA

4914. Erikson, T. A., Pure shock environmental testing of condensed-phase, unstable materials, *ARS J.* **30,** 2, 190–191 (Tech. Notes), Feb. 1960.

Acoustics

(See also Revs. 4537, 4555, 4764, 4797)

4915. Kurtze, G., and Bolt, R. H., On the interaction between plate bending waves and their radiation load (in English), Akustische Beihefte no. 1, 238–242, 1959.

Authors study the influence of surrounding media on transverse motion of plates. General formulas are derived for the speed of waves generated by plate bending. Two cases are presented. These are an infinite plate loaded on one or both sides by an infinite medium, and an infinite plate loaded on one or both sides by a layer of finite thickness terminated by an infinite impedance. The interaction of plate and medium is analyzed by use of a transverse wave impedance defined as ratio of applied pressure to resulting transverse velocity at any point under the forced wave motion generated by the pressure of a hypothetical plane wave propagating parallel to the plate. This impedance is calculated both for the plate and the medium. Appropriate combinations of these two impedances can be utilized for various physical situations.

Results given are applicable to analysis of sound propagation in certain duct configurations and to propagation along and through walls at frequencies near coincidence.

R. B. Grant, USA

4916. Einspruch, N. G., and Truell, R., Scattering of a plane longitudinal wave by a spherical fluid obstacle in an elastic medium, *J. Acoust. Soc. Amer.* **32,** 2, 214–220, Feb. 1960.

Incident and scattered wave potentials in the elastic solid, and the transmitted wave potential in the ideal fluid obstacle, are expressed as series expansions in products of Legendre functions by spherical Bessel functions of first or third kind. Boundary conditions at the obstacle surface yield expressions for coefficients. Limiting case of Rayleigh scattering (long waves, small obstacles) is adequately described by three terms. Total scattered energy rate divided by the geometrical cross section of obstacle and by the energy rate per unit area in the incident wave yields the normalized scattering cross section of the fluid sphere.

W. W. Soroka, USA

4917. Kuznetsov, V. K., A new method for solving the problem of the sound field in a fluid wedge, *Soviet Phys.-Acoustics* **5,** 2, 171–176, Nov. 1959. (Translation of *Akust. Zh., USSR* **5,** 2, 170–175, Apr./June 1959 by Amer. Inst. Phys., New York, N. Y.)

Cylindrical coordinates (r, θ, z) are used, and harmonic dependence on the angle θ is assumed. The two-dimensional waves in the (r, z) plane correspond, after transformation, to an index of refraction depending on r. For incidence from infinity, the result agrees with a previously known solution. For a two-dimensional pencil of rays within the wedge, refraction and interference patterns are calculated. Supporting experimental data are cited.

P. Rudnick, USA

4918. Schultz, T. J., Effect of altitude on output of sound sources, *Noise Control* **5,** 3, 17–21, 54, May 1959.

Author describes radiation of acoustic power into media of various densities and sound propagation velocities, typical of varying altitude conditions in high performance jet aircraft. The outputs of various types of sound sources are examined. The behavior of internal mechanisms such as loudspeakers and headphones is considered in the situation of sudden cabin decompression and its probable effect on communication. Noise external to the aircraft cabin (jet noise, boundary-layer noise) is described also, and the analytic justification for the conclusions is presented.

J. S. Arnold, USA

4919. Skudrzyk, E. J., and Haddle, G. P., Noise production in a turbulent boundary layer by smooth and rough surfaces, *J. Acoust. Soc. Amer.* **32,** 1, 19–34, Jan. 1960.

Experimental and theoretical studies show that, in a turbulent boundary layer, the effective velocity fluctuations are about 4% of the free-stream velocity. Flow-noise studies with a rotating cylinder in a water tunnel were used as a basis for predicting the levels of boundary-layer noise and the variation in noise produced by surface roughness as speed and frequency vary. Simple noise measurements were used to analyze certain properties of the boundary layer, such as its thickness.

R. C. Binder, USA

4920. Greatrex, F. B., and Brown, D. M., Progress in jet engine noise reduction, Advances in Aeronautical Sciences, Vol. 1 (Proc. of the First International Congress in the Aeronautical Sciences, Madrid, Sept. 8–13, 1958), Pergamon Press, 1959, 364–392.

4921. Neely, K. K., Etkin, B., and Ribner, H. S., Noise research in Canada: physical and bioacoustic, Advances in Aeronautical Sciences, Vol. 1 (Proc. of the First International Congress in the Aeronautical Sciences, Madrid, Sept. 8–13, 1958), Pergamon Press, 1959, 393–441.

4922. Littlewood, W., Noise in air transport, Advances in Aeronautical Sciences, Vol. 1 (Proc. of the First International Congress in the Aeronautical Sciences, Madrid, Sept. 8–13, 1958), Pergamon Press, 1959, 442–461.

4923. Mariner, T., Spot treatment: effects of absorbent material near the source, *Noise Control* **5,** 3, 37–41, 56–57, May 1959.

Author describes effects of varying the location of sound-absorbing materials upon reverberation in rooms. The proximity of the absorbing material to the sound source affects the energy that is absorbed directly and thus to an extent controls the sound level that results. The judicious placement of materials to intercept direct and reflected energy in particular situations is necessary to achieve optimum sound-level reduction. An analytical justification for the method of acoustic treatment is presented.

J. S. Arnold, USA

4924. Burov, V. A., and Krasil'nikov, V. A., On the absorption of high-intensity ultrasonic waves in water, *Soviet Phys.-Doklady* **4,** 1, 190–193, Aug. 1959. (Translation of *Dokladi Akad. Nauk SSSR (N.S.)* **124,** 3, 571–574, Jan./Feb. 1959 by Amer. Inst. Phys., Inc., New York, N. Y.)

The attenuation at 1, 1.5, and 2 Mc for initial intensities of 50, 100, and 250 watt/cm² was measured calorimetrically within about 20%. The distance of onset of the stable sawtooth wave form is well predicted by Riemann's theory, and the attenuation of the sawtooth agrees with the theory of I. Rudnick and R. Leonard, [*J. Acoust. Soc. Amer.* **24,** p. 456, 1952]. Previous work along these lines has been at lower intensities.

M. Greenspan, USA

4925. Stopskii, S. B., An acoustic method for the investigation of cavitation in hydroturbines (in Russian), Hydroturbine construction, Gidroturbostroenie **4,** Moscow-Leningrad, Mashgiz, 1957, 93–102; *Ref. Zh. Mekh.* no. 2, 1959, Rev. 1504.

A method is described for investigating the spread of cavitation on models in working conditions by recording the sound waves appearing in the flow of liquid. The sound waves in the turbine are the results of the rotation of the blades in the liquid with a range of vibration frequencies of 1–100 Hertz in natural conditions and of 3000–5000 Hertz when using models, of vortex formation during the flow about the blades with a continuous range of vibration frequencies, the amplitudes of which are dependent on the velocity of flow in the sixth degree, and of cavitation phenomena creating impact vibrations when the bubbles coalesce. Spectral analysis shows that the spectrum of the last-named vibrations contains ultrasonic vibrations. Vibrations of very low frequency were observable in turbulent cavitation manifestations. In the method worked out the ultrasonic vibrations were studied by means of a piezo-testing probe connected to a resonance amplifier with a frequency for the whole device of 10 to 400 K Hertz. Investigations showed that the required relation between the frequency band Δf and its carrier capacity f was 0.01 to 0.25. The voltage at the amplifier end was measured by a lamp voltmeter. A comparison of the cavitation characteristics obtained on a model of the turbine by the energy and ultrasonic methods indicated that the sharp change of the energy characteristics with $\sigma = \sigma_{cr}$, conditioned by the developed cavitation, agrees with the sharp fall of power of ultra sound in the sonic screen. This moment can be well-established by the use of a narrow band amplifier with the relation $\Delta f/f \approx 0.06 = 0.25$ (with components for the frequencies of the spectrum of the cavitation noise of 10 Hertz to 2.5 M Hertz).

R. G. Perel'man

Courtesy Referativnyi Zhurnal, USSR

Porous Media

(See also Revs. 4405, 4654, 4812)

4926. Karadi, G., and Orloczi, I., Loss through seepage in irrigation canals (in Hungarian), *Hidrologiai Kozlony* **39,** 5, 381–391, Oct. 1959.

Seepage from irrigation canals is identified as steady or unsteady, either free or impeded by the natural ground water table. Definite theoretical formulas are developed for the free steady flow. Authors derive formulas for the free unsteady seepage. Computations of seepage in presence of a variable ground water are less definite, and formulas are more complex. In the second part authors check existing formulas and find that for the case of free steady flow all formulas can be reduced to one, analogous to the Darcy formula. An additional reduction coefficient is to be used for lined channels.

S. Kolupaila, USA

4927. Suan'-le, Lu., Seepage through earth dams on permeable soil when permeability of dam is different from foundation (in Russian), *Gidrotekh. Stroit.* **27,** 8, 38–43, Aug. 1958.

Author investigates seepage through permeable dam and foundation, without any diaphragm, core or apron. Two methods are developed. In the first, four segments are separated: entrance, up-

stream part, central part, and exit portion. Balance of water flow is computed for each segment in both directions. The sum gives total outflow, and solution of equations shows depression curve. In the second method the upstream part is substituted by a rectangular section, which simplifies solutions. Results of theoretical computations were checked experimentally by the electric analogy. Permeability ratio was varied between 1/200 to 600, foundation depth between 0.05 and 0.3 of the base width. Results obtained were closer than by any other methods. Article ends with some suggestions concerning diaphragms.

S. Kolupaila, USA

Book—4928. Druzhinin, N. I., The method of electro-hydrodynamic analogy and its application in filtration analysis (in Russian), Moscow-Leningrad, Gosenergoizdat, 1956, 356 pp. + illus. 12 r. 25k.; *Ref. Zh. Mekh.* no. 9, 1958, Rev. 10174.

The monograph gives a general exposition of the principles of the E.G.D.A. [E.G.D.A. (Russian Letters)—*Electro-Hydro-dynamic-analysis.*] method and its applications in the modelling of filtration problems. The problems discussed include the degree of experimental accuracy attainable with the E.G.D.A. equipment and the selection of electrically conducting materials. The long experience of the All-Soviet Scientific Research Establishment for Hydraulic Engineering, gained during the investigation of a variety of filtration problems arising in the designing, construction and exploitation of hydraulic engineering structures, is presented in a generalized form. Considerable space is devoted to an exposition of the author's own theoretical and experimental investigation and conclusions. The exposition is illustrated by numerous examples.

Chapters I, II and III are of an introductory nature and include a brief historical survey. Chapter IV deals with the electrically-conducting materials used in modelling filtration phenomena. Attention is principally paid to aqueous and ferrous electrolytes; the electrochemical processes developing therein are discussed in detail, and means are indicated for dealing with disturbing, electrochemical phenomena occurring in the model arrangements. Chapter V examines and discusses different types of E.G.D.A. experimental equipment, and analyzes the sensitivity of response of the instruments used. The E.G.D.A. instruments using electrically-conducting paper strip are not discussed. Chapters VI and VII describe means and methods for constructing models for the investigation of filtration problems and setting up the appropriate boundary conditions, as well as the experimental methods. The problems discussed include those of three-dimensional, pressure and gravity, filtration flows, in homogeneous and inhomogeneous soils. The modelling of unsteady, gravity seepage is separately demonstrated. Chapter VIII discusses the problem of the attainable accuracy of measurement by the E.G.D.A. method of filtration flow volumes and lines of equal head for models composed of electrolytes and other ionic conductors. Recommendations are made for increasing the accuracy of researches by the E.G.D.A. method.

L. F. Fil'chakov

Courtesy Referativnyi Zhurnal, USSR

4929. Matveyenko, T. I., Problems of the unsteady seepage of a liquid from a channel (in Russian), Nauchn. Yazhegodnik, Odessk. In-ta Odessa, p. 114, 1957; *Ref. Zh. Mekh.* no. 9, 1958, Rev. 10131.

A formulation of two problems of unsteady, three-dimensional seepage in the case of abrupt change in the water level of the channels. The problem is examined from the hydraulic aspect, on the assumption of a horizontal barrier, and is reduced to solution of the equation of thermal conductivity in a semiplane or a zone. No solutions of the problems are given.

G. K. Mikhailov

Courtesy Referativnyi Zhurnal, USSR

4930. Abdullayeva, A. A., The relative permeability of water-bearing strata (in Azerb.), AzerbSSR Elmler Akad. Khoberleri, no. 7, 17–29, 1957; *Ref. Zh. Mekh.* no. 9, 1958, Rev. 10156.

A presentation of experimental results on the relationship between the water-permeability factor k and a number of physical and physico-chemical factors. The test sands were taken from the virgin beds on the Apsheron Peninsula, and the quartz sand supplied from the town of Lyubertsy. The displacement of the water was effected under a pressure gradient of $\Delta p = 0.6$ atm/m, since a further increase in the gradient did not lead to any increase in the water yield. The part of the ground water was played by seawater, also used for displacing petroleum oils; ground water from the PC series of the productive (oil-bearing) sands of the Apsheron Peninsula was also used. The experiments were made for both the presence and absence of ground water. Curves are plotted for the relationship between the coefficient k and the carbonate content in the porous medium ρ, for paraffin oil, inactive, subactive, active and superactive petroleum. Author arrives at the following conclusions: An increase in the activity of the petroleum and the carbonate content of the sands, as well as a decrease in the contained ground water, lowers the value of the coefficient k. Independently of the ground water content, the drop in k with increasing carbonate content proceeds intensively only as far as a certain limit. Ground water increases k more in the case of sea water than in the case of high alkalinity. Under otherwise identical conditions, the values of k are higher for alkaline than for sea water. The difference in the value of k for these two kinds of water increases with decreasing ground water content, increasing carbonate content of the sands, and higher activity of the petroleum. On this basis, author considers it advisable to use alkaline waters and waters improved by the addition of surface-active substances (activators) for strata containing high-carbonate rocks, highly-active petroleums, and low ground water content (low water table). To ensure higher values of k, it is suggested the activity of the residual petroleum in the region of the bottom of a pressure well be depressed by various additions or that this petroleum be displaced by an unpolarized liquid hydrocarbon (kerosene) or a subactive petroleum.

V. L. Danilov

Courtesy Referativnyi Zhurnal, USSR

4931. Abasov, M. T., and Dzalilov, K. N., An approximate method of solving certain problems of underground hydrodynamics (in Azerb.), *Me'ruzeler AzerbSSR Elmler Akad.* **13**, 3, 247–251, 1957; *Ref. Zh. Mekh.* no. 9, 1958, Rev. 10117.

The method applied is that of finite integral transformations developed by G. A. Grünberg and proposed by K. F. Shirinov ["Approximate methods for the solution of some three-dimensional filtration problems," Thesis, Moscow State University, 1955], as a means of approximating the potential on individual sections of the wall of a borehole, for the solution of the three-dimensional problem of steady percolation of a homogeneous liquid into a borehole in the presence of a plug not extending to the roof of the producing stratum. The permeabilities of the stratum and the plug are assumed to be constant, but different. The stratum is circular, with impermeable roof and floor. The solution of the problem is found by integrating the differential equations for the potentials Φ_1 and Φ_2, in the regions of the stratum and the plug. A constant potential is assumed for the part of the borehole wall not covered by the plug, while at the boundary of the plug and the stratum the potential is approximated by a trigonometric polynomial, the indeterminate terms of which are determined from the integral expressions describing the equality of the flow volumes over the intervals of the boundary. The final equations of the potentials Φ_1 and Φ_2 are obtained in the form of a series of products of Bessel and trigonometric functions.

A. L. Khein

Courtesy Referativnyi Zhurnal, USSR

Geophysics, Hydrology, Oceanography, Meteorology

(See also Revs. 4537, 4540, 4546, 4653, 4737, 4741, 4826, 4831, 4837)

4932. Collins, F., Plane compressional Voigt waves, *Geophysics* **25,** 2, 483–504, Apr. 1960.

In a Voigt solid stresses are linear combinations of strain and rate of strain. Author treats one-dimensional wave resulting from instantaneous Dirac-delta disturbance in these solids. Presentation is unduly lengthy and complicated. No mention is made of extensive Japanese work [Cf. especially the papers by Sezawa and by Kanai, *Bull. Earthquake Res. Inst., Tokyo Univ.*, 1929 to date], which leads to simpler expressions. Author expresses hope that treatment of spherical waves in same solids will eventually do away with discrepancies between Ricker's theory and observed waves in seismic exploration.

E. Rosenblueth, Mexico

4933. Clough, R. W., Dynamic effects of earthquakes, *Proc. Amer. Soc. Civ. Engrs.* **86,** ST4 (*J. Struct. Div.*), 49–65, Apr. 1960.

The principal factors controlling the dynamic response of structures to earthquakes are summarized.

From author's summary

4934. Angona, F. A., Two-dimensional modeling and its application to seismic problems, *Geophysics* **25,** 2, 468–482, Apr. 1960.

Laboratory seismograms of a fault model demonstrate the mechanism for diffraction and clearly show the difference in amplitude decay and moveout between a reflection and a diffraction. The inverted order and the deflection to the side of reflected energy from a curved reflector with a buried focus is demonstrated. A comparison is made of seismograms from a simple fault model and from one combining a fault with curved reflectors leading to it. The curved surfaces increase the overlap of the reflected events and mask the fault. Modeling techniques, involving the control of the reflection coefficient between layers by thickness variations and the control of the propagation velocity through a layer by combining two or more materials into a laminated sheet, are demonstrated. From author's summary

4935. Bycroft, G. N., Murphy, M. J., and Brown, K. J., Electrical analog for earthquake yield spectra, *Proc. Amer. Soc. Civ. Engrs.* **85,** EM 4 (*J. Engng. Mech. Div.*), 43–64, Oct. 1959.

Paper describes an electrical model for the simulation of a damped single-degree-of-freedom elastoplastic structure. Required nonlinearity is achieved by use of a biased-diode capacitor network. Earthquake input data are fed from accelogram recordings by means of a photoelectric device previously developed for study of the corresponding linear representation of structures. The analog network provides for convenient measurement of total yield excursion, maximum yield displacement and residual permanent set. Results of computations for a particular earthquake recording are given and the effects of variation in some parameters are investigated and discussed.

D. E. Hatton, Australia

4936. Parkhomenko, I. S., A study on models of the passage of a head wave through a layer with increased velocity (in Russian), *Izv. Akad. Nauk SSSR, Ser. Geofiz.* no. 2, 196–209, 1958; *Ref. Zh. Mekh.* no. 2, 1959, Rev. 1744.

Seismic waves in solid layered media are reproduced in model form by using the known method of ultrasonic impulses. In the model water serves as the medium; "layers" are placed in the water made of metal or plexiglass. The velocity of propagation of longitudinal waves in these "layers" is greater than in water. Those changes in the head wave in water are investigated which are associated with passage of the wave through successive layers with increasing velocities of propagation. It is stated that if the thickness d of an intermediate layer is less than the dominant length λ of the ultrasonic impulse in the layer then the form of the impulse in passing through the layer does not change. Changes are noticeable when $d/\lambda > 0.23$ if the angle θ for the fall of the wave is less than the critical θp, and when $d/\lambda > 0.04$ if this angle exceeds the critical. In the first case the form of the passing wave re-establishes itself anew when $d/\lambda > \sim 2$. The seismic drift of the wave does not change practically, that is the radiating rays remain approximately rectilinear, when a layer is introduced into the water having a thickness of $d/\lambda < 0.23$ if $\theta < \theta p$, or a thickness of $d/\lambda < 0.04$ if $\theta > \theta p$. With further increases in the thickness of the layer the seismic drift increases with the increase of d/λ when the transposition of the ray which has passed in relation to the incident ray attains one to two lengths of the wave. The author refers to the qualitative agreement of these observations with the results of L. M. Brekhovskii's calculations [*Uspekhi Fiz. Nauk*, **50,** no. 4, 1953] and of B. S. Chekin's [*Izv. Akad. Nauk SSSR, Ser. Geofiz.* nol 4, 449–457, 1957]. Yu. V. Riznichenko

Courtesy Referativnyi Zhurnal, USSR

4937. Brenner, J. L., Fulton, R., and Sherman, N., Symmetry of the earth's figure, *ARS J.* **30,** 3, 278–279 (Tech. Notes), Mar. 1960.

By means of a special numerical integration carried out for nine hundred revolutions, it is shown that the oblateness of Earth causes long period changes in the shape, size and inclination of the osculating orbit of the Vanguard I satellite (1958 Beta two). Unless many determinations of these parameters are made per revolution, the effect of an Earth with equatorial symmetry can imitate in period, amplitude and phase the effect which might be expected from a "pear-shaped" potential. This result, which has been verified by independent analysis using an appropriate perturbation theory, shows that published evidence does not support the hypothesis that Earth's mass distribution is asymmetric with respect to its equatorial plane.

From authors' summary

Book—4938. Schaffernak, F., Hydrology [Hydrographie], Graz, Akademische Druck- u. Verlagsanstalt, 1960, ix + 438 pp. $9.00.

Book, first published in 1935, was the best treatise on hydrology and hydrometry in Europe. Continuous demand warranted this new unchanged edition (the author died in 1951). The book is of unquestionable value, and libraries may use the opportunity to acquire it. Contents, divided in 3 parts, are: observations and gathering of hydrographic, meteorologic, and morphologic (sediment, silt, ice) data; arrangement of collected data, analytical and statistical (correlation, empirical formulas, empirical curves, graphical presentation); utilization of data (river regime, runoff, maximum and minimum discharge, available energy, forecasts, artificial changes). Quality of reprint is very high, even better than original edition. S. Kolupaila, USA

4939. Neglyad, K. V., and Vorontsov, E. A., Experiments to apply wave-measuring devices for the measurement of waves from the shore (in Russian), *Trudi Odessk. Gidrometeorol. In-ta* no. 13, 47–59, 1957; *Ref. Zh. Mekh.* no. 2, 1959, Rev. 1434.

This is a description of experiments carried out to test the applicability of optical wave meters of different types to wave-measuring at a number of stations on the Black Sea foreshore. In order to attain the necessary degree of precision in measuring the

wave elements with the Shuleikin-Bodganovich wavemeter a recommendation is put forward to reduce the fineness of graduation of the instrument in order to increase the focal distance of the monocular. This remark also applies to Ivanov's wavemeter with perspectometer. The most efficient long-term installation for wave motion measurement for both the above instruments was found to be a spherical buoy attached to an anchor by means of a chain of sufficient length to act as shock absorber, the chain being 1.5 times the depth of the sea at the site of the experiments. Experience showed that conical-ended cylindrical buoys get submerged even with a heavy tide flowing, and in stormy weather tend to break away. In order to get satisfactory observations, using the Shuleikin optical wavemeter, fitted with a "spider-web" line, a recommendation is made to build a special tower as close as possible to the level of the water, provided the general natural sea-bed level does not vary very much. The height of the tower is determined in relation to its distance from the site under observation. If the natural place of the installation is exceptionally high then it is proposed to increase the focal length of the instruments used. B. Kh. Glukhovskii

Courtesy Referativnyi Zhurnal, USSR

4940. Laboish, V. G., The flow around islands by sea currents (in Russian), *Vestn. Leningrad In-ta* no. 18, 107–118, 1957; *Ref. Zh. Mekh.* no. 2, 1959, Rev. 1440.

A solution is obtained for the problem of the discontinuous flow around a body by a plane stationary flow when taking into account the Earth's rotation. The case is investigated when the external flow is parallel to the shore's outline and has a constant velocity; and also the case where the velocity of the flow beyond the limits of the boundary layer varies in accordance with the linear principle. The question is gone into on the possibility of the currents from the shore. Finally, the conclusion is reached that where the shore lies to the right, while the current flows around the protuberances in the shore's contour then, with determined values of some characteristic parameter, the flow may be continuous. If the shore lies to the left of the current, flow breaks away easily on meeting the projections on the shore's contour. In the southern hemisphere these processes, of course, operate in the reverse way. The deductions are illustrated from geographical instances.

S. S. Voit

Courtesy Referativnyi Zhurnal, USSR

4941. Tsikunov, V. A., A simplified theory for the convective mixing in the upper layers of the sea (in Russian), *Trudi Okeanogr. In-ta* no. 42, 115–127, 1958; *Ref. Zh. Mekh.* no. 2, 1959, Rev. 1444.

An investigation is made of the convective mixing in a certain upper layer of the sea at a depth h, caused by the cooling of the sea's surface. The layer in which the mixing takes place is taken to be homogeneous. It is assumed that convection penetrates to that level below which the density of the water is greater than in the upper mixed layer. Taking a theoretically idealized viewpoint, author disregards the processes of heat conductivity and salt diffusion in the underlying layer, the heat exchange and salt exchange through the surface of the division between the upper and lower layers. A detailed deduction is given for the equation for thermal equilibrium. Five equations serve the determination during the period of cooling of the temperature, salinity in the upper and lower layers and the thickness of the upper mixed layer: (1) the equation for thermal equilibrium; (2) the equation for the salinity equilibrium, analogous to (1); (3) a simplified equation for the heat conductivity of the lower layers, where no account is taken of the turbulent exchange in comparison with the advection exchange; (4) an equation analogous to (3) for the salinity of the underlying layers; (5) the equation establishing the density in relation to the temperature and the salinity for the upper layer of the mixed region. The velocities of the flow are assumed to be known. The solution of this system is given and proposals are made to adopt practical (in the main graphical) methods for the calculations of the unknown functions for the case where all the functions coming into the equation depend only on the vertical coordinates and on time. G. P. Kurbatkin

Courtesy Referativnyi Zhurnal, USSR

4942. Groves, G. V., Determination of upper-atmosphere air density and scale height from satellite observations, *Proc. Roy. Soc. Lond.* (*A*) **252,** 1268, 16–27, Aug. 1959.

Paper presents a method for calculating the air density, starting from the measurement of the rate of change of satellite period. It is assumed that the logarithm of the air density is a quadratic function of the height. The density calculated at 500 Km above sea level is 18 times greater than that of the 1956 ARDC Model Atmosphere, but agrees in the order of magnitude with that of the new 1959 ARCD Model Atmosphere. A. Miele, USA

4943. Groves, G. V., Determination of upper-atmosphere air-density profile from satellite observations, *Proc. Roy. Soc. Lond.* (*A*) **252,** 1268, 28–34, Aug. 1959.

Paper presents a method for calculating the variation of the density with the height, starting from experimental observations of satellite orbits. A solution is presented first in terms of the change in perigee distance and then in terms of the change in the radius of the Earth at the sub-perigee point.

A. Miele, USA

4944. Mikhnevich, V. V., Danilin, B. S., Repnev, A. I., and Sokolov, V. A., Some results of the determination of the structural parameters of the atmosphere using the third Soviet artificial earth satellite, NASA TT F-13, 19 pp., May 1960.

This paper presents a study of a part of the results of the determination of the density of the atmosphere, which were obtained from manometer measurements on the third Soviet artificial satellite. From authors' summary

4945. Shklovskiy, I. S., and Kurt, V. G., The determination of the density of the atmosphere at an altitude of 430 kilometers by the sodium vapor diffusion method NASA TT F-15, 13 pp., Apr. 1960.

A method is described for the determination of atmospheric density from observation of the diffusion of sodium vapors over a large range of altitudes. The lower limit of this range can apparently be taken at around 200 kilometers. The upper limiting region where the method is applicable is apparently between 500 and 600 kilometers. From authors' summary

Naval Architecture and Marine Engineering

(See also Revs. 4659, 4737)

Book—4946. Saunders, H. E., Hydrodynamics in ship design, Vols. 1 and 2, New York, Society of Naval Architects and Marine Engineers, 1957, xxxv + 648 pp.; xxiii + 980 pp. $30 (the set)

These volumes represent the first attempt in the long history of naval architecture to combine—in the form of a comprehensive treatment—the magical skills of classical and empirical ship design techniques with theoretical and scientific methods. In the past twenty or so years, many attempts have been made by hydrodynamicists to penetrate the well-established but at times somewhat inconsistent rule-of-thumb design practices with sound analytical papers applicable to certain narrow fields of ship design

but prior to this work neither a naval architect nor a hydrodynamicist was brave enough to attack the Herculean task of presenting the profession with a treatise of the subject.

Captain Harold E. Saunders, USN (Ret), approaches the totality of ship design problems from the point of view of a naval architect. His close contact with theoreticians combined with almost 50 years of fleet, design and research experience eminently and uniquely qualifies him to author this book. The fruits of eight years of devoted and enthusiastic work sponsored by the Society of Naval Architects and Marine Engineers and by the Bureau of Ships, U. S. Navy, are the two volumes under review.

The first volume discusses some of the applicable hydrodynamic principles in two parts: "Flow phenomena and motion of the simple ship" and "Flow around and motion of an actual ship." The 37 chapters and 420 superbly clear figures of the first volume attempt to give the basic physical picture in a language understandable to the practicing naval architect. The style of the writing, the technical expressions used, and the author's philosophy are unique, uncompromising, and often slightly unconventional for the hydrodynamicist. Rigid adherence to the principle of *docendo discimus* results in a thoroughness at the price of verbosity. The commendable effort to remove any elements of mystery from the mind of the reader who has not been trained in the field of hydrodynamics is one of the primary aims of the book. The author accomplishes this by stressing detailed physical descriptions instead of concise mathematical treatments.

The second volume in 39 chapters and with 463 illustrations discusses "Prediction procedures and reference data" and "Hydrodynamics applied to the design of a ship." Unquestionably this volume contains the subject which is author's forte, i.e., the preliminary design of a large merchant vessel, the actual design of a screw propeller, and the design of two alternative types of a motorboat. Detailed discussion of all steps, necessary design diagrams, computational procedures and numerical results lead the reader through Scylla and Charybdis. It is characteristic of the book that when problems are solved without complete knowledge of the underlying facts by using the engineer's intuition, this is plainly brought out in the text by clearly separating logical scientific facts on one hand and empirical or intuitive arguments on the other. The author finds, one way or another, answers to all design problems and lives by Heaviside's famous principle: "Shall I refuse my dinner because I do not fully understand the process of digestion?"

Publication of the third volume of the book is expected in 1961. It will discuss maneuvering, towing, unsteady straight line motion, waves and seakeeping. The profession is grateful to this savant and to his sponsors for the monumental undertaking which reflects not only facts but also a philosophical approach to ship design.

V. G. Szebehely, USA

4947. Ridgely-Nevitt, C., Geometrically similar models—an investigation of some problems resulting from their resistance values, *Inter. Shipbldg. Prog.* **6,** 59, 311-339, July 1959.

This is a study of ship models and their resistance. The problem is how to correlate the resistances of geometrically similar models with each other, and ultimately how to extrapolate them to full scale. Author found that many existing data had to be discarded because of inadequate control of turbulence stimulation. New experiments were made in which attention was paid to this difficulty. The customary analysis of ship resistance assumes that the resistance coefficient is the sum of a skin friction term (scaling according to Reynolds similarity) and of a wave term (scaling according to Froude similarity). There is no theoretical reason why this assumption should be exactly true and author finds that it is not exactly true in his experiments. Also each hull shape is found to require a separate "friction line," a result in agreement with earlier experiments.

The paper treats 11 displacement hull forms and 2 planing forms. The investigation was limited to model sizes and to smooth surfaces. This work is of value since it provides additional evidence of the difficulties which necessarily arise when accurate extrapolation from small models to large models and to full scale is attempted; these difficulties can no longer be ignored.

F. Ursell, England

4948. Kan, S., Tsuchida, K., Yokoo, K., and Ito, T., Model experiments of a super-tanker in still and rough water, *Inter. Shipbldg. Prog.* **6,** 55, 127-138, Mar. 1959.

4949. Mikhailov, V. N., Resistance of a ship's hull due to the roughness of the sheathing (in Russian), *Sudostroenie* no. 1, 10-15, 1958; *Ref. Zh. Mekh.* no. 2, 1959, Rev. 1448.

This is discussion on the results of theoretical and experimental investigations on the supplementary resistance due to different forms of roughness of the hull of a ship: roughness due to the painting of the plates of the outer sheath of a ship's hull, roughness due to the wavy nature of the outer sheath of the vessel, roughness due to excisions in the hull and to welded seams. For all the above constituents of resistance simple empirical formulas are derived. With the use of the proposed method an approximate calculation was carried out for the "additives to roughness" for two all-welded freshly painted ships, when the values of supplementary resistance obtained by computational means were sufficiently close as regards magnitude to the "additives," determined on the basis of the analysis of the results of quick natural tests on ship-prototypes. It was shown that in modern all-welded ships the predominant influence on the resistance was found to be the unevenness of the painted surface of the outer sheath and the flanged apertures and excisions in the hull of a ship.

A. S. Ginevskii

Courtesy Referativnyi Zhurnal, USSR

4950. Stepanyuk, E. I., and Velednitskii, I. O., New data on the water resistance to the motion of barges being towed "in-line" (in Russian), *Rechn. Transport* no. 3, 18-20, 1958; *Ref. Zh. Mekh.* no. 2, 1959, Rev. 1450.

Investigations were carried out in 1956 on the water resistance to the motion of models of ship "in-line" formations in the tanks of The Central Scientific Institute for Research of the River Fleet and the Leningrad Research Institute for Water Transport. The results of the experiments showed that the least resistance was encountered by the first barge and the greatest by the hindmost. To verify these results field experiments were carried out in 1957 by the above institutes on the river Volga with three barges, all being of one type—two sand-carrying and one pushing. Curves were drawn on the basis of the data obtained, from which it was seen that the resistance of the first barge was in all cases less than of the single barge. The resistance of the second and third barge "in-line" was greater or equal to the resistance of the single barge. Here the resistance of the last barge "in-line" is always higher than the resistance of the single barge. The results obtained from the above experiments confirmed, in general, the deductions made on the basis of experiments made with models. Authors explain these results by pointing out that when the barges are in motion a discontinuous flow occurs with the formation of an intensive vortex wake. The vortex resistance to the first barge with a second barge following it will decrease while the vortex resistance to the second barge will increase. The calculation of the residual resistance using I. O. Velednitski's method confirmed these concepts.

E. V. Sukacheva

Courtesy Referativnyi Zhurnal, USSR

4951. Wadlin, K. L., and Christopher, K. W., A method for calculation of hydrodynamic lift for submerged and planing rectangular lifting surfaces, NASA TR R-14, 13 pp., 1959.

See AMR 11(1958), Rev. 2652.

4952. Radosavljevic, L. B., The comparison of the frequencies of free oscillations of a ship in a seaway based on the coupled and uncoupled differential equations of motion, *Inter. Shipbldg. Prog.* **6,** 54, 63-71, Feb. 1959.

The problem dealt with by the author is to estimate the influence of the neglected "coupling" upon the frequencies of free oscillations.

By introducing the principal coordinates, the author has proposed an analysis of the problem as a function of three parameters: (a) $\varkappa_1 = x_c/i$, the ratio of the abscissa of the center of gravity of the flotation surface and of the radius of gyration of the flotation surface for transverse axis; (b) $\varkappa_2 = i_1/i$, the ratio of the radius of gyration of the mass of the ship for transverse axis and the radius of gyration of the flotation surface for transverse axis; (c) K the coefficient of added masses.

Author has shown that in certain cases the frequencies of the free oscillations cannot be determined from uncoupled equations of motion. However, such a treatment, connected with various assumptions, is usual in engineering practice, and even widely recommended in technical literature.

Author has introduced the coefficients μ_1 and μ_2, in order to be able to estimate this influence. The analytical expressions derived by the author were used for calculations of numerical values of those coefficients, the variations of parameters $\varkappa_1$, $\varkappa_2$ and K being within the limits encountered in practice.

The values of the coefficients μ_1 and μ_2 are given in tables, whereas the plotted diagrams may be useful for practice.

From author's summary by W. H. Hoppmann II, USA

4953. Vorob'ev, A. P., Some investigations of a ship's rolling by using the methods of the theory of probability (in Russian), *Ucb. Zap. LGU* no. 217, 3-16, 1957; *Ref. Zb. Mekb.* no. 2, 1959, Rev. 1455.

An investigation is carried out on the rolling of a ship due to irregular two-dimensional wave action. The methods used were those for the theory of random processes. In carrying this out the agitation moment is assigned either by the progression of the sinusoidal disturbances with jet amplitudes and phases, or by the superposition of a finite number of random periodic disturbances with different frequencies. An evaluation is made of the probability of divergence at a given moment of time of the random stationary process of rolling from the given period, determined by fixing the size of the angle of heeling.

I. P. Lyubomirov
Courtesy Referativnyi Zhurnal, USSR

4954. Tsybin, V. P., Stability of a ship on a running wave (in Russian), *Trudi Murmanskogo Vyssb. Morekhodn. Ucb-sbcba* no. 1, 80-87, 1957; *Ref. Zb. Mekb.* no. 2, 1959, Rev. 1458.

Hydrostatic calculations were made for various positions in equilibrium of a straight-sided ship with a cylindrical insert on a two-dimensional trachoidal wave. The results show that a ship positioned on the crest of a wave, the length of which was equal to the length of the ship, has a significantly lower transverse metacentric height and stability at large angles of heeling than when floating on calm water. It is presumed that such marked heeling of the ship, due to a fall to such a degree in the stability, might occur if the crest of the wave should be situated between the ninth and the eleventh theoretical transverse ribs of the ship's framework over a period of time equal to one quarter of the period for the free-roll oscillations of the ship. On this basis a calculation is made for the critical speed of motion of the ship on to the incoming wave which might be expected to result in the appearance of dangerous heeling. One case is analyzed of the capsizing of a ship on an incoming wave.

I. P. Lyubomilov
Courtesy Referativnyi Zhurnal, USSR

4955. Savichev, P A., Effect of the addition of cargo on the dynamic stability of a ship (in Russian), *Sudostroenie* no. 11, 16-18, 1957; *Ref. Zb. Mekb.* no. 2, 1959, Rev. 1456.

A method is described for calculating the required amount of ballast which should be taken aboard a ship with the object of increasing its dynamic stability up to the danger-free norm, corresponding to the principles of normalizing the stability. The paper continues with a comparison of this method with a method adopted with the same object in view based on successive approximations. The conclusion arrived at is that the method proposed has marked advantages from the point of view of labor saving in the computational work.

G. E. Pavlenko
Courtesy Referativnyi Zhurnal, USSR

4956. Tachmindji, A. J., The axial velocity field of an optimum infinitely bladed propeller, David W. Taylor Mod. Basin Rep. 1294, 18 pp., Jan. 1959.

In contrast with the usual propeller simulation as a sink disk, ring vortices extending back to infinity are employed to investigate the axial velocities ahead of the propeller. A series of such families with different strengths and radii are used to simulate a radial variation in blade loading. Comparison with the sink disk results in the case of uniform loading is shown to indicate significant differences in the radial distribution of the velocities.

J. M. Robertson, USA

4957. Stubbs, S. M., and Hoffman, E. L., A brief investigation of a hydro-ski stablized hydrofoil system on a model of a twin-engine amphibian, NASA TN D-220, 21 pp., Feb. 1960.

A hydrodynamic investigation of a supercavitating hydrofoil system mounted on a 1/8-size powered dynamic model of a twin-engine amphibian was conducted in the Langley towing tanks. The system had a main supercavitating hydrofoil mounted with twin ventilating struts located at the tips of the hydrofoil. Two hydro-skis mounted forward of the hull were used as stabilizing planing surfaces. The investigation was made to determine some of the resistance characteristics during take-off and stability characteristics during take-off and landing. Landing tests with 10° model trim were stable in calm water and in waves 2 feet by 80 feet (full scale) for yaw angles of 0° and 5° and in waves 3 feet by 120 feet for 0° yaw. The system was capable of stable take-offs with available thrust and control.

From authors' summary

4958. Chu, W.-H., and Abramson, H. N., Hydrodynamic theories of ship slamming—review and extension, Southwest Res. Inst., Dept. Appl. Mech., Engng. Analysis Section TR-1, 41 pp., Nov. 1959.

A critical review and evaluation of existing hydrodynamic theories of body-water impact is presented. It is shown, partly by comparison with available experimental data, that fitting methods are adequate only for bodies of reasonably large deadrise angle during later stages of the impact process.

From authors' summary by J. C. Burgess, USA

4959. Gray, R. C., The dynamics of launching, *N. E. Coast Engrs. Inst. Ship. Trans.* **76,** 3, 131-156, Jan. 1960.

This paper is an analysis of the data obtained during the launch of a 32,000-ton deadweight tanker. The equations of motion describing the launch of the ship are derived and then used to construct diagrams, one showing the forces acting on the ship and the

other showing the balance of energy of the system; both diagrams are plotted to a base of "distance travelled" by the ship.

An estimate is made from this analysis of the force of the water resistance acting on the ship and of the quantity of the "entrained" water moving with the ship. The effect of the entrained water on the distance travelled by the ship during the launch, and some methods of estimating the distance travelled are examined.

From author's summary

4960. Brock, J. S., Transfer of local axial load into bulkhead plating, David W. Taylor Mod. Basin Rep. 1300, 21 pp., Mar. 1959.

Bulkheads on surface ships supporting concentrated loads are loaded on the stiffeners. Author investigates the stress distribution of such loads into the plating using experimental stress analysis approach. Two models constructed of cellulose nitrate have been analyzed by photoelastic method. The results indicate that the concentrated loads are absorbed into the plating within the first deckheight. Author recommends that bulkhead stiffeners subject to axial load should have a taper of not more than one deckheight.

R. Szilard, USA

Friction, Lubrication and Wear

(See also Revs. 4522, 4608)

4961. Nakayama, Y., and Endo, H., Effect of finishing grade on the wear of diesel engine cylinder wall, *Bull. JSME* **2,** 8, 584–593, Nov. 1959.

Authors used a diesel engine of six cylinders which were constructed in identical conditions except for the finishing grade of their inner walls; three of the cylinders had fine-bored surfaces, and the other three had honed surfaces. Using this engine intermittently for one year and a half, they made the following measurements: (1) Cylinder: The amount of wear was determined by measuring the inner diameter at ten various positions with an air-micrometer. The roughness of the surface was measured simultaneously with the wear determinations by using an instrument of a diaphragm-type air-micrometer. (2) Piston: The wear was determined by measuring the diameter of the upper, middle and the bottom parts, and the total wear was obtained by weighing the piston with a balance. The wear of the ring grooves was also determined carefully. The temperature distribution on the piston was determined from the change of hardness during the operation. (3) Piston Ring: The wear was measured by two methods: diameter and weight measurements. The pressure distribution on the cylinder wall was determined by measuring the peripherial shape of the ring. (4) Compression Pressure: The Okill Pressure Indicator at 400 rpm was used.

From the results obtained, the authors reached the following conclusions: (1) the wear of a honed cylinder is smaller than that of a fine-bored cylinder at the initial period, but with regard to the total wear for a long period, no difference was found; (2) for the piston wear, ring wear, tension and pressure distribution, there were no differences between the two cylinders with different finishing grades; (3) the ordinary honed, cast-iron cylinders shorten the fitting time.

H. Eyring, USA

4962. Vagramian, A. S., New method for measuring the temperature on the friction surface between dissimilar metals (in Russian), *Vestnik Mash.* **38,** 7, 13–15, 1958.

With modern research on friction and wear it is important to measure the surface temperature of the sliding materials as a function of the contact pressure and the velocity. If the materials are electrically conducting different metals, the thermoelectric voltage between the sliding surfaces is a measure of the temperature. Author has improved this well-known method by using two contacts. The materials to be tested are pressed against a rotating disk and the voltage between the specimens is measured. The disk serves the purpose to close the electric circuit and if it is of the same material as one of the specimens, no spurious voltages can occur. After a description of the apparatus, empirical formulas are presented for the combinations steel versus Babbit metal, steel vs. cast-iron, steel vs. bronze, cast-iron vs. aluminum, steel vs. aluminum, bronze vs. cast-iron, cast-iron vs. Babbit metal and bronze vs. Babbit metal; relating the surface temperatures to the velocity (1.2–3.6 m/sec) and the contact pressure (20–100 kg/mm^2).

R. G. Boiten, Holland

4963. Drobni, J., Dynamical testing of mechanisms in consideration of friction power and moment of friction (in Hungarian), *Gép* **11,** 10, 379–382, Oct. 1959.

4964. Draigor, D. A., and Val'chuk, G. I., Hardening of metals during friction and the strength of steel during repeatedly-changing loadings (in Russian), *Sb. Tr. In-ta Stroit. Mekh. Akad. Nauk USSR* no. 22, 93–99, 1956; *Ref. Zh. Mekh.* no. 2, 1959, Rev. 2077.

An investigation is made on the influence of the process of hardening of the rubbing surfaces on the fatigue resistance and durability. The durability coefficient K was determined by the formula $K = K_1/N_0$, where N_1 is the number of cycles effected before fracture when centers of hardening are present, N_0 is the number of cycles effected before fracture of the ground specimens without any reaction by friction forces and when centers of hardening are absent. Polishing of the surface of the specimen with the elimination of centers of hardening resulted in the re-establishment of durability. Durability was not re-established by polishing when there was prolonged friction action on steels of a metastable structure.

B. Ya. Tarasov

Courtesy Referativnyi Zhurnal, USSR

4965. Blinnik, S. I., On the selection of admissible contact stresses in static loads (in Russian), *Vestnik Mash.* **39,** 1, 28–30, Jan. 1959.

Author gives a table presenting maximum or mean values of admissible contact stresses for some typical machine details used in practice (ball and roller bearings, geared wheels, runners of overhead travelling crane, and so on).

Z. Horak, Czechoslovakia

4966. Dowson, D., and Higginson, G. R., A numerical solution to the elasto-hydrodynamic problem, *J. Mech. Engng. Sci.* **1,** 1, 6–15, June 1959.

Authors dealt with the problem of steady rolling and/or sliding of two highly loaded elastic cylinders of infinite length separated by a lubricating film under isothermal conditions. Because of the high pressure the elastic deformations of the cylinders and the viscosity-pressure-dependence of the lubricant are to be considered. $p = 0$ at the inlet and $p = \partial p/\partial x = 0$ at the outlet are the boundary conditions. The difficulty in solving this problem comes from the fact that the pressure distribution cannot be determined from Reynolds equation alone, because the film thickness $h = h_c + x^2/2R_1 + x^2/2R_2 + v_1 + v_2$ is unknown by reason of the elastic displacements in y-direction at the two cylinders v_1 and v_2 which depend on the unknown pressure distribution in form of the elasticity equations for plane strain.

To overcome this obstacle authors employ following procedure. They assume a plausible pressure distribution, determine the appropriate film-thickness function from Reynolds equation, and calculate the elastic displacements v_1 and v_2 originating from this pressure distribution from the elasticity equations. Then they compare the film-thickness function calculated from Reynolds equation with that determined from the elastic displacements. In

the first case the assumed pressure distribution represents the solution of the problem. But if the functions do not harmonize, the calculation is repeated with a new assumed pressure distribution and this procedure is continued until an agreement between the film-thickness functions is obtained.

In this way the pressure distributions and the film-thickness functions are determined for four cases. The cases differ only with regard to the loads. The results clearly show that the pressure distribution becomes more and more similar to the Hertzian pressure distribution, and the film thickness more and more constant, if the load is increased. Further it is seen that at very high loads the film thickness becomes insensitive to increase in load. A comparison shows that considering the elasticity and the viscosity-pressure dependence involves a pressure distribution which consists of much greater pressures and extends over a greater zone between the cylinders than the pressure distributions for the same minimum film thickness resulting from theories which neglect these facts. U. Rost, Germany

4967. Ganesha Rao, H. M., A study of journal bearings, Part 1, *J. Instn. Engrs. India* **40,** 5(Part 2), 187–193, Jan. 1960.

Paper is concerned with a summary presentation of the well-known problems of a full journal of infinite length. The load, torque, lubricant flow, heat generation and temperature problems are all given in more or less the usual way. The author does not point out the serious shortcomings of these formulations in their application to real problems. The work is clearly written and obviously by one not at complete ease with English. There are a few minor typographical errors. F. R. Archibald, USA

4968. Raven, F. H., and Wehe, R. L., Influence of shaft deflection and surface roughness on load-carrying capacity of plain journal bearings, NASA TN D-4, 54 pp., Aug. 1959.

The load capacity of a full journal bearing with flexible shaft is evaluated mathematically by using the criterion of first local metallic contact. A method for determining the optimum length-diameter ratio of a bearing for maximum load capacity, based both on shaft deflection and bearing surface roughness, is given. Analytical calculations of bearing load capacity based on shaft deflection are compared with experimental capacities obtained by Battelle Memorial Institute and are shown to be of equal order of magnitude (from authors' summary).

Reviewer feels that authors' treatment should be revised. The reason is that authors erroneously assume that, in accordance with Dubois and Ocvirk's short-bearing theory, minimum film thickness, h_{min}, would be proportional to $(\mu N/p)^{1/2}$ (where μ is viscosity, N rotational speed, and p unit load). In the limiting cases considered, that is those approaching impending contact between journal and bearing, h_{min} is, according to both experimental evidence and more exact theories, proportional to $\mu N/p$ itself, and not to its square root. H. Blok, Holland

4969. Kut'kov, A. A., Apparatus for determining the starting moment of rolling bearings, *Measurement Techniques* no. 6, 659–662, Mar. 1960. (Translation of *Izmeritel'naia Tekhnika, USSR* no. 6, 39–41, Nov./Dec. 1958 by Instrument Society of America, Pittsburgh 22, Pa.)

4970. Holland, J., Contribution to the determination of the lubrication conditions in internal combustion engines (in German), *VDI Forschungsheft* **25,** 475, 32 pp., 1959.

Analytical and experimental results are given and compared for performance characteristics of engine bearings. The analysis is basically a combination of the effects of journal rotation and fluid displacement on the bearing capacity and volumetric flow of lubricant. The analysis seems both sound and practical. The experimental work is carefully described.

Wide use is made of the results obtained by a select group of earlier workers in this field. References to more recent contributions by research groups outside the author's country might have given the analysis more breadth. E. J. McBride, USA

Letters to the Editor

4971. Re: AMR **13**(1960), Rev. 1306: **Howe, J. T., Some finite difference solutions of the laminar compressible boundary layer showing the effects of upstream transpiration cooling,** NASA Memo 2-26-59A, 33 pp., Feb. 1959.

Author has called reviewer's attention to a possible misinterpretation of his review. Reviewer noted that at the junction of the porous and impermeable regions the boundary-layer equations are invalid, but did not wish to imply that the solutions of these equations are thereby invalidated. The word "locally" should have been added to the last sentence of the review. Reviewer regrets omission and possible misinterpretation resulting therefrom. P. A. Libby, USA

4972. Re: AMR **13**(1960), Rev. 3065: **Chambre, P. L., Nonlinear heat transfer problem,** *J. Appl. Phys.* **30,** 11, 1683–1688, Nov. 1959.

AMR **13**(1960), Rev. 3066: **Abarbanel, S. S., On some problems in radiative heat transfer,** AFOSR TN 59-531 (Mass. Inst. Technol., Fluid Dynamics Res. Group Rep. 59-1; ASTIA AD 216 538), 205 pp., Apr. 1959

Reviews following the above bibliographical headings should be reversed. Hence, review no. 3065 should have followed bibliographical heading no. 3066 and review no. 3066 should have followed bibliographical heading no. 3065.

The editors regret this error.

Books Received for Review

Applied Geophysics [Prikladnaya geofizika], Vol. 24, Leningrad, Gosudarstvennoe Nauchno-Tekhnicheskoe Izdatel'stvo, 1960, 261 pp. 13 r. 25 k.

Automatic controls [Avtomaticheskoe Regulirovanie], Book 36, Moskva-Leningrad, Gosudarstvennoe Nauchno-Tekhnicheskoe Izdatel'stvo, 1960, 139 pp. 3r. 75 k. (Paperbound)

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BRENEMAN, J. W., Mechanics, 3rd ed., New York, McGraw-Hill Book Co., Inc., 1960, x + 262 pp. $5.50.

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COLLAR, A. R., AND TINKLER, J., Editors, Hypersonic flow (Proceedings of the 11th Symposium of the Colston Research Society, University of Bristol, England, 6/8 April 1959), New York, Academic Press, Inc., 1960, xv + 432 pp. $13.50.

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JASTROW, R., edited by, The exploration of space (Symposium on Space Physics, Washington, D. C., Apr. 29–30, 1959), New York, The Macmillan Company, 1960, 160 pp. $5.50.

IPSEN, D. C., Units, dimensions and dimensionless numbers, New York, McGraw-Hill Book Co., Inc., 1960, xii + 256 pp. $6.50.

Industrial controls [Prom'shlennaya telemekhanika], Moskva, Izdatel'stvo Akademii Nauk SSSR, 1960, 285 pp. 18 R. 55 k.

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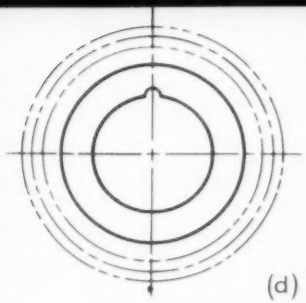

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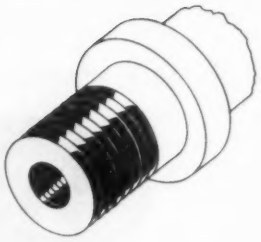

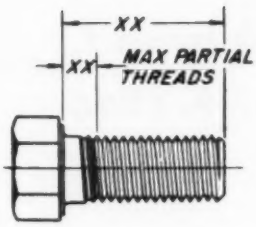

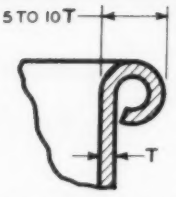

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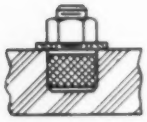

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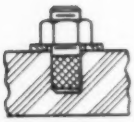

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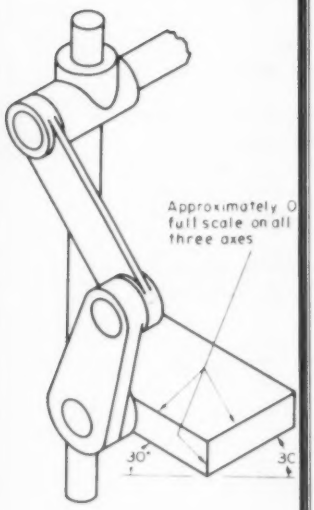

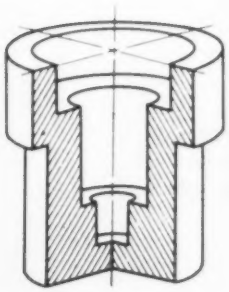

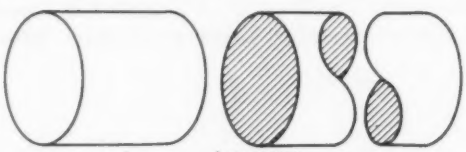

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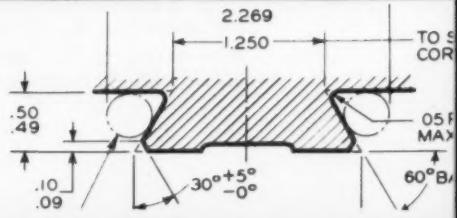

Whether you need information on the fundamental principles of dimensioning, layout practices, pictorial sketching, projection, control and form tolerancing of geometric surfaces, the preparation of diagrams, or the special requirements for metal stampings, plastics, etc., you will find it in these twelve sections of the

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SIZE AND FORMAT (Section 1), Y14.1 — 1957. **$1.00**
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LINE CONVENTIONS, SECTIONING AND LETTERING (Section 2), Y14.2 — 1957. **$1.50**
Scope: Line symbols; visible and hidden lines; section, center and dimension lines; extension lines and leaders; cutting plane lines; break and phantom lines; section lining on detail and on assembly drawings; direction and spacing of general purpose section lines; the cutting plane; full and half sections; location of sectional views; lines behind the cutting plane; broken-out, revolved, removed, offset, auxiliary, and thin sections; sections through webs, shafts, bolts, pins; foresnortened projections and rotated features; intersections in section; sizes of lettering for different purposes.

PROJECTIONS (Section 3), Y14.3 — 1957. **$1.50**
Covering arrangement of views for multiple view orthographic projections, this section describes and illustrates practices in the choice and arrangement of the views; use of partial, alternate, removed and revolved views; auxiliary views; conventional breaks; and rounded and filleted intersections; developed views; descriptive geometry applications.

PICTORIAL DRAWING (Section 4), Y14.4 — 1957. **$1.50**
Here the various kinds of pictorial drawings are defined and the correct method of using them described. Axonometric, oblique, and perspective drawings are fully considered, and a number of examples presented showing the variety of positions in which the axes may be placed. Suggestions are given on the proper pictorial arrangement of sectional views, thread representation, the use of break lines, indicating fillets and rounds, unidirectional and pictorial plane dimensioning, shading, and phantom drawing.

DIMENSIONING AND NOTES (Section 5), Y14.5 — 1957. **$2.00**
Deals with the rules, principles, and methods used for specifying design requirements on drawings; illustrates how dimensions and notes should be used; and includes dimensioning practices for the control and form tolerancing of geometric surfaces.

SCREW THREADS (Section 6), Y14.6 — 1957. **$1.50**
Presents the approved methods of placing screw thread data on drawings and a considerable amount of information on thread tolerances useful to draftsmen. Typical drawing notes are shown along with specific practices for dimensioning.

GEARS, SPLINES, AND SERRATIONS (Section 7), Y14.7 — 1958. **$1.50**
Although this section is not intended to be a text book on gear design, it does give reasons for the methods shown and specified, so that the user will have some basic understanding of the need for more detailed gear-tooth dimensioning and specifications. Also included are the delineation and specification of Splines and Serrations.

FORGINGS (Section 9), Y14.9 — 1958. **$1.50**
In this standard is the needed information on preparing drawings for forgings, arranged in logical sequence and in usable form. The coverage includes properties of forgings, limitations, materials for forgings, production methods, parting line, forging plane, draft, fillets and corners, radii, web thickness, tolerances, forging drawings, including the parting line, unequal die depths, ribs, end draft for cylinders, intersections, and dimensioning.

METAL STAMPINGS (Section 10), Y14.10 — 1959. **$1.50**
Sets forth practices used by small parts manufacturers in the production of metal stampings as produced on standard types of punch presses. Here too, will be found help in laying out and delineating a product which will be subjected to metal stamping processes. References to methods of fabrication, die clearances, etc., are also included.

PLASTICS (Section 11), Y14.11 — 1958. **$1.50**
This section discusses basic preferred design and drafting practices specifically related to parts formed of plastic material. To assist the designer and draftsman in the delineation of plastic part drawings, a brief discussion of materials, manufacturing processes, and operations is included along with design and drawing hints for parts which are formed of the molding and laminating type plastics. Tolerance is also discussed from a general standpoint.

ELECTRICAL DIAGRAMS FOR ELECTRONICS AND COMMUNICATIONS (Section 15), Y14.15 — 1960. **$1.50**
Besides definitions and general information on electrical diagrams, this standard contains specific help and guidance in the preparation of single-line diagrams and schematic diagrams used by the electronics and communications industries. Items covered include layout; ground symbols; terminals; indication of parts; reference designations; methods of expressing resistance, capacitance, and inductance values; functional identification of parts; test points; additional circuit information; and single-line diagrams for microwave circuits.

FLUID POWER DIAGRAMS (Section 17), Y14.17 — 1959. **$1.50**
This section not only establishes drafting practice for fluid power diagrams but also furnishes, for the first time, a comprehensive text and reference work on the subject. It explains in detail the data and notes which should accompany symbols and lines to make the diagram meet specific requirements. Types covered are: Pictorial diagram which may be used for quotation and piping the installation; cutaway diagram which is most often used for instruction purposes; graphical diagram which may be used for quotation, piping the installation, and for analyzing circuit operation; and a combination diagram which is used to emphasize purpose and operation of a portion of a system. Several examples of complete diagrams of each of these four types are included, also symbol data form ASA Y32.10.

Supplementing the recommendations are numerous sketches along with diagrams illustrating good drafting practices.

Price of these twelve sections and binder: $19.00 **20% discount to ASME members.**

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American Standards

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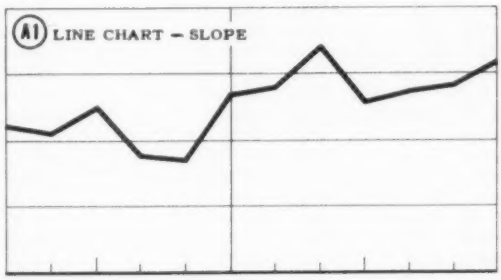
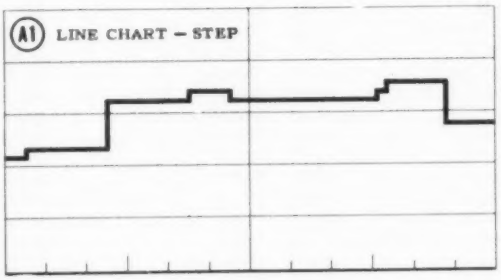
Charts

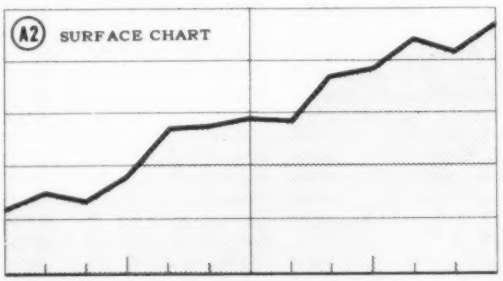
TIME SERIES CHARTS, Y15.2 — 1960. **$3.50**

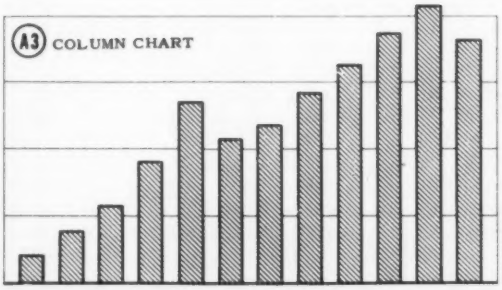
Covering charts that include time as one of the principal elements, this manual offers information and guidance on the best current practice in layout and design; shape and ruling of the grid; choice of the scale and presentation of the data to scale; design and use of curves in the scale; preparing and using titles, subtitles, and notes; curve and chart captions.

The discussion covers line charts and the standard practices for their design, column and surface charts and the procedures that apply to these two forms, and time series line charts having a logarithmic amount of scale.









Illustrations

ILLUSTRATIONS FOR PUBLICATION AND PROJECTION, Y15.1 — 1959. **$2.00**

This standard shows pictorially how to apply good design principles in preparing illustrations (or slides) of specific subjects; provides a simple, standard, drafting-form system for making a properly scaled working draft of an illustration (graph, chart, sketch, etc.); makes feasible the use of a single drawing for either a slide or a printed illustration; and includes easy-to-use information on drafting techniques. The results possible with modern electric typewriters and lettering guides are illustrated.

Symbols

The following American Standards list the LETTER SYMBOLS which have been approved for use in technical works (including textbooks).

Letter Symbols for Hydraulics, Y10.2 — 1958. $1.00

Letter Symbols for Mechanics for Solid Bodies, Z10.3 — 1948. 1.00

Letter Symbols for Structural Analysis, Z10.8 — 1949. 1.00

Letter Symbols for Heat and Thermodynamics, Y10.4 — 1957. 1.50

Letter Symbols for Petroleum Reservoir Engineering and Electric Logging, Y10.15 — 1958. 1.50

Letter Symbols for Physics, Z10.6 — 1948. 2.00

Letter Symbols for Aeronautical Sciences, Y10.7 — 1954. 2.00

Letter Symbols for Radio, Y10.9 — 1953. 1.00

Letter Symbols for Meteorology, Y10.10 — 1953. 1.00

Letter Symbols for Acoustics, Y10.11 — 1953. (Reaffirmed 1959.) 1.00

Letter Symbols for Chemical Engineering, Y10.12 — 1955. 1.50

Letter Symbols for Rocket Propulsion, Y10.14 — 1959. 2.00

The GRAPHICAL SYMBOLS in the American Standards, listed below, provide the means of placing concise information on drawings and plans.

Graphical Symbols for Welding, Y 32.3 — 1959. $3.00
Also included are letter designations for different types of cutting and welding processes, and a welding symbol chart.

Graphical Symbols for Plumbing, Y32.4 — 1955. $1.00

Graphical Symbols for Pipe Fittings, Valves and Piping, Z32.2.3 — 1949. (Reaffirmed 1953.) $1.00

Graphical Symbols for Heating, Ventilating, and Air Conditioning, Z32.2.4 — 1949. $1.50

Graphical Symbols for Use on Railroad Maps and Profiles, Y32.7 — 1957. $1.50

Graphical Symbols for Heat-Power Apparatus, Z32.2.6 — 1950. (Reaffirmed 1956.) $1.00

Graphical Symbols for Fluid Power Diagrams, Y32.10 — 1958. $1.50
These symbols are for use on hydraulic and pneumatic diagrams. Definitions, sample circuits, diagrams and indexes are included.

Metallizing Symbols, Y32.12 — 1960. $1.50
These symbols are intended to specify extent and nature of each operation, surface preparation, spraying, etc.

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